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RAPID TRANSIT TUNNEL SUB-CONTRACTS have been awarded as follows: Carnegie Steel Co. is to furnish the 72,955 tons of structural steel and iron to be used; the Sicilian Asphalt Co. will lay 775,795 sq. yds. of asphalt water-proofing, and the United Building Material Co will furnish the Portland and other cement. To the Degnon-McLean Construction Co. is awarded Sections 1 and 2, including the post-office loop to Chambers St. and Chambers to Great Jones, on Elm St., for $1,250,000 and $2,000,000, including in the latter $500,000 for shifting sewers and $100,000 for shifting 36-in. main and other water pipe. Mr. E. J. Farrell has Section 7, from 103d to 110th St. and Lenox Ave.; and Section 8, from 110th St. to 100 ft. beyond 135th St. and Lenox Ave.; the two bids approximate $1,600,000, including for this 4,100 ft. of rock tunnel. Mr. John C. Rogers has Section 9, joining the Farrell contract, going under the Harlem River and then east to Brook Ave.; the price is about $2,000,000. Mr. John Shields has Section 11, from 104th St. to 125th St.; no price named. Mr. L. B. McCabe has Section 13, from 133d St. to 181st St., and Section 14, from 181st St. to Hillside Ave. The sub-contracts for Sections 3, 4, 5, 6 and 10, 12 are not yet announced.

THE NEW YORK RAPID TRANSIT COMMISSION has its authority extended to the entire territory of Greater New York by a bill approved by Mayor Van Wyck on April 13. This will enable the Commission to undertake the proposed tunnel railways under the East River to Brooklyn. A bill permitting the refunding of $8,000,000 of county bonds now in the Sinking Fund was approved on the same date and will provide funds for the proposed tunnel.

A TELEGRAPH POLE TAX, of $5 each, is proposed by the Chicago aldermen; and where wires are laid underground the tax is to be 15 cts. per lin ft. per year. The promoters of the scheme expect to obtain an annual revenue of $256,000 from these sources. At the present time the Western Union and Postal telegraph companies do not pay Chicago anything in the form of compensation for privileges; but the Chicago Telephone Co. does pay taxes and is exempt from the proposed ordinance.

THE NEW EAST RIVER BRIDGE APPROACHES will be the next portion of this great structure to be placed under contract. The Commissioners have issued a preliminary announcement to intending bidders, stating that the proposal forms, plans and specifications will be ready for inspection at 84 Broadway, Brooklyn, on April 23, 1900. The time for closing the bids will be announced at a later date.

THE NEW SYDNEY HARBOR BRIDGE PLANS and proposals, as they have been issued by the New South Wales Department of Public Works, can be examined at the publication office of Engineering News. The documents comprise a general site plan of the bridge, sections of borings along the approximate line of the bridge, and the printed conditions under which proposals and designs must be submitted.

THE SONE RIVER BRIDGE at Dehri, India, which was opened for traffic on March 22, has a total length of 10,052 ft., with a waterway of 9,300 ft. This bridge is a double track structure and forms the completing link of the new branch of the East Indian Ry., from Mogul Serai to Gya, the line on both sides having been finished for some time past. Beyond its great length the bridge presents no unusual structural features. Its total cost was about $120 per lin. ft. Construction was begun Feb. 22, 1897, and the bridge was completed Feb. 22, 1900.

THE CUBAN CENTRAL RAILWAY is a system proposed by a syndicate, at the head of which is Sir William Van Horne, for many years President of the Canadian Pacific and now Chairman of the Board of Directors of that system. This proposed Cuban railway will be about 900 miles long and run from end to end of the island, with numerous tributary lines tapping inland towns. It is stated that construction will not be commenced unless the United States continues in control of the island. Sir William and his associates say that they have little faith in the development of Cuba by the Cubans alone.

IMPROVED ELEVATOR FACILITIES for New York Harbor are provided for in a comprehensive scheme which has been set on foot by Mr. Edward F. Cragin. Mr. Cragin has secured a lease from the New Jersey Riparian Commission for about 90 acres of land forming the shoal between Ellis and Bedloe's islands in New York Harbor. This shoal has a depth of only 3½ ft. below water at places, and is nowhere at a great depth. The bottom, it is stated, is hard and will form a good foundation for heavy structures, while railway connections can easly be made from the New Jersey shore. The proposition is to build grain elevators, piers and docks on this shoal, which will accommodate the largest ocean grain carriers, and to make the location the center of the grain trans-shipping business of the port. According to the estimates of Mr. Cragin the work will cost about $3,000,000, and he announces that he has ample backing and that there need be no doubt about the scheme being carried out. He estimates a saving of 1½ cts. per bushel and probably more from the proposed plant in handling grain at New York. Mr. Cragin will be remembered by most of our readers as having obtained the concession for a trans-isthmian canal which was formerly held by the Maritime Canal Co.

THE IMPROVEMENT OF THE CHICAGO RIVER on the basis of securing a channel 26 ft. deep and 200 ft. wide from Lake St. to Ashland Ave., has been abandoned by the Drainage Board on account of the high cost as estimated by Mr. Thos. T. Johnston, Consulting Engineer to the Board. The estimates amounted to $10,092,085 for widening by taking land and buildings on the east side; and $11,132,738 if the work should be done on the west side of the present channel of the river. The Board has, however, decided upon the expenditure of $3,000,000 for the improvement of the river, this sum being all that is available for the work as a sanitary necessity. With this sum new bridges, all of the bascule type, will be built to replace existing structures, and the river will be widened and deepened at certain points. All this work will be done with a view to the ultimate establishing of a channel 200 ft. wide and 30 ft. deep.

TWO NEW SHIP CANAL PROJECTS are before Congress. One, introduced by Congressman Mudd, of Maryland, would provide for the construction of the Maryland & Delaware Free Ship Canal to cost not exceeding $10,000,000. The canal would be not less than 100 ft. wide on the bottom, and 30 ft. deep; with locks 60 ft. wide and 600 ft. long in the clear. It would connect deep water in the Delaware Bay and in the Chesapeake. The other bill, introduced by Congressman P. C. Chandler, of Massachusetts, is for a ship canal starting in Weymouth Fore River, at Boston Harbor, and ending at the Taunton River and Narragansett Bay, at Fall River. The whole distance is about 37½ miles, with the canal proper 19 miles long. The present sea-route between these points is 170 miles on the inside route, and 225 miles by the outside route. It would admit the Sound steamers to Boston Harbor. Mr. Chandler offers many arguments for its construction, for the benefit of commerce, and its advantages in time of war; but he submits no estimates, though calling for a canal of the Suez dimensions and 26 ft. deep.

THE CAPE COD CANAL BILL was defeated in the Massachusetts Senate on April 12 by a vote of 15 to 14.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Bellefonte & Snowshoe R. R., near Snowshoe, Pa., on April 12. A broken rail caused a heavy freight engine to leave the track on a curve. The engine went over a ten-foot embankment into a marsh. Three men were killed and one seriously injured.

THREE BOILERS EXPLODED at the Riverside Iron Works, Wheeling, W. Va., on April 13, wrecking two boiler houses, the blowing engine house, the cast house and furnace and injuring a rolling mill. The wreck of the blowing engines will probably cause the furnaces to chill. The total property loss is estimated at $250,000.

A FOUR-STORY BUILDING COLLAPSED at Pittsburg, Pa., on April 13, killing three persons. A partition wall had recently been removed and columns and girders substituted. It is said that the upper floors were overloaded. The building was one of those rebuilt after the big fire of 1845.

A VERY HEAVY RAINFALL is reported from New Orleans as the result of the storms of April 15-16. In New Orleans 6½ ins. fell in 12 hours; and in the same time 8 ins. fell at Amite, 80 miles distant, and 9¼ ins. at Meriden, Miss. From noon on April 15 to noon on April 17 the total rainfall in Southeastern Mississippi was 13¾ ins.

THE "RAINLESS REGION" OF PERU is in 5° S. latitude, near the city of Payta and on the coast. It did rain for 24 hours in February, 1899; but this was the first rainfall in eight years; and the average duration between showers is seven years. Fogs are quite frequent, and the flora is poor, seven out of nine plants found being annuals. The seeds of the latter sometimes remain in the ground for seven years before germinating. The Peruvian cotton grows, as with its long roots it can go without water for seven years; it furnishes abundant and profitable crops and supports the people.

THE WATER SUPPLY OF THE CITY OF MEXICO is described in "El Imparcial," of that city, from the time of the Aztecs, who obtained their water from the springs of of Chapultepec. In 1576 the Santa Fe springs were used and these still furnish 6,000 liters of water per minute; and in 1786 to these were added the Desierto and Leones springs, now yielding 8,000 liters per minute, and these springs supplied the city until 1888. In the latter year the city added by purchase the Alberca Grande de Chapultepec, with 7,000 liters per minute; and, in 1896, the city acquired a water supply of 9,000 liters from the Hacienda de los Morales, and also 800 liters per minute from the Concesion Chousal. In 1899-1900 it united with the Morales supply water from Rio Hondo, giving together 30,000 liters per minute. When all of these springs, etc., can be utilized the city will have a supply of 55,000 liters per minute, or nearly 20,000,000 U. S. gallons per day for 400,000 inhabitants; or 51 gallons per day per head. To the above supply must be added 14,000 liters per minute, flowing from 1,039 artesian wells. The distribution of this supply is poor, says "El Imparcial," as to one ward with 40,000 inhabitants is given only 77 liters per day per head, while another ward with 8,000 inhabitants receives 219 liters. The city now has in it 6,630 houses supplied by some 62 miles of pipes of all dimensions. For supplying water to the city of Mexico in 1900, the estimated cost is $405,780, including $200,000 paid for the Morales springs. The water tax yields $250,000 per year. A new plan is being made for a better distribution of water.

THE WATER CONSUMPTION OF LONDON during December averaged 200,250,000 gallons per day. Estimating the population at 6,020,845, this is equivalent to a consumption of 33.26 gallons per capita per day.

THE WORKS OF THE LONG ISLAND WATER SUPply Co. came into the possession of the city of New York a few days ago. They were built in 1881 to supply the town of New Lots, which in 1886 was annexed to Brooklyn as the 26th Ward. In December, 1890, the city officials of Brooklyn agreed to buy the plant for $1,250,000, but were prevented from doing so by the courts. In January, 1893, a commission appointed for the purpose decided that the city should pay $570,000 for the works. The award has been in the courts more or less of the time since, finally reaching the U. S. Supreme Court. The award was upheld and was the final basis of payment, plus about $104,000 of interest.

DEVELOPMENT OF NIAGARA POWER IN ONTARIO is provided for by a concession recently granted to a company by the Commissioners of Queen Victoria Park at Niagara Falls. The company is permitted to take water from the Welland River near its junction with the Niagara River and carry it by an open canal to the bluff between Dufferin Islands and Cedar Island, where the power house will be erected. The canal and power house is to be completed within six years. When more power is demanded than can be developed at this point, a second canal can be built from the power house through the park to a point just below Table Rock, where a second power house may be established. The company is to pay for the concession annual rentals as follows: $15,000 for the first 10,000 HP.; $10,000 for the next 10,000 HP.; $2,500 additional for the next 10,000 HP., and $50,000 for whatever may be developed at the lower power house. The total available horse-power is estimated at 300,000. Gen. Geo. S. Field, M. Am. Soc. C. E., 452 Delaware Ave., Buffalo, N. Y., formerly connected with the Union Bridge Co., is named as Vice-President and General Manager of the company.

THE FAILURE OF THE AUSTIN DAM.

In our last issue we gave a brief telegraphic account of the failure of the great masonry dam and the subsequent wrecking of the power house at Austin, Tex. Since then we have secured from our correspondent at Austin, Prof. T. U. Taylor, of the University of Texas, a full report on the failure, in addition to which we have received highly interesting volunteer reports from two engineers who happened to be in Austin at the time of the failure, Messrs. H. M. Chance, M. Am. Inst. M. E., 418 Drexel Building, Philadelphia, and A. B. Roome, Inspector of the Continental Insurance Co., of New York city. Each of these gentlemen has supplied us with photographs, for the most part differing in time or point of view, thus giving us an unusual opportunity to make selections showing the dam and power house under varying conditions.*

FIG. 1.—VIEW OF AUSTIN DAM AND POWER HOUSE FROM WEST BANK OF RIVER, TAKEN SOME TIME BEFORE ACCIDENT.
(White outline on power house indicates recent break in wall.)

Figs. 1, 2 and 3 were all taken some time previous to the failure. Fig. 1 is an exceptionally fine view of both the dam and power house, from the west end, while Figs. 2 and 3 show the dam with very thin and very thick sheets of water, respectively, passing over its crest. Fig. 3 is of peculiar interest, having been taken on June 7, 1899, when a flood nearly equal to the one at the time of the failure passed over the dam. At the time this view was taken the water on the crest was 9.25 ft. deep, but at 9 p. m. of the same day it reached a level of 9.8 ft., or only 1.27 less than that just before the recent break.

Fig. 4 is a sort of key to the whole story, being a sketch plan, by Professor Taylor, of the failure. It should be noted that it differs in one respect from the sketch in our last issue, prepared by us from Professor Taylor's telegraphic report, in that the detached portion left standing was near the center instead of at the east end of the break.

Fig. 5 is a view of the break, sent us by Professor Taylor, with a note on the back "3 min. after break." It is not so clear or on so large a scale as could be desired, being a snap-shot, with a small camera, but it certainly gives ample opportunity for a study of what happened in a very few minutes after the break occurred. Figs. 6, 7, 8 and 9 are views of the break in the dam at various intervals after its occurrence; thus, with Fig. 5, showing the conditions about 3 minutes, 1, 2 and 24 hours after the parting of the dam. A study of these views, and of our special reports and the reports of the eye-witnesses seems to indicate without question that much, if not practically all, of the 50'-ft. break moved bodily down-stream in two sections, and that at least the portion shown in the views in its new position was broken off nearly to the bottom. The best evidence of this, as to the detached part still standing, is its height in relation to the parts in place, and its nearly vertical position. As to the whole of the two parts broken out, had the break been far above the base, in the curved down-stream face, overturning would almost certainly have occurred.

Figs. 10 to 12 are designed more particularly to show the effect of the break on the power house. In Fig. 10, taken some two hours after the dam broke, the power house appears to be practically uninjured, but about midnight, or some 13 hours after the break, a large part of the west wall fell down, wrecking the north end, which contained the lighting plant, as shown in Figs. 11 and 12, which views were taken Sunday, April 8.

With the above comment on the views, designed to aid in unifying what follows, we leave the views and several reports on the failure to tell their own story, lest by vain repetitions we add confusion to what has been so well told by our correspondents and by the eye-witnesses.

Following the various accounts of the failure are letters from a number of engineers connected with the Austin dam, their several parts in its design being set forth in our last issue. These communications were sent in response to letters from us stating that our columns were open to them for such appropriate comments on the failure as they might see fit to make—as they are to all our readers.

Special Report on the Failure of the Dam, Prepared by Prof. T. U. Taylor,* Assoc. M. Am. Soc. C. E.

At Austin the Colorado River emerges from a mountainous country, which extends for a distance of over 200 miles in a northwesterly direction. The channel above Austin, for the most part, is a sinuous gorge, held in by limestone mountains and hills. Austin is at the foot hills of a long range of mountains, 40,000 square miles of which afford a drainage area for the Colorado. It is fed by the Perdinales, the Llano, the San Saba, the Conchos, and Pecos Bayou. The configuration of the country is such that the water runs off rapidly into the streams.

From 1 p. m., April 6, to 4 a. m., April 7, there was a rainfall of 5 ins. at and in the vicinity of Austin, in a mountainous country, on ground already wet. In addition to this, tremendous rains fell all along the Colorado and its tributaries from Austin as far up as Llano, a distance of over 100 miles. The Colorado rose rapidly, and by 10 a. m. Saturday (April 7) it was apparent that the dam was to withstand the biggest flood since water first wetted its crest on May 16, 1893. At this hour the water level of the lake was over 10 ft. above the crest of the dam and was rising rapidly. The greatest previous flood height occurred at 9 p. m., June 7, 1899, when the

Fig. 2.—A Few Inches of Water Flowing Over the Crest.

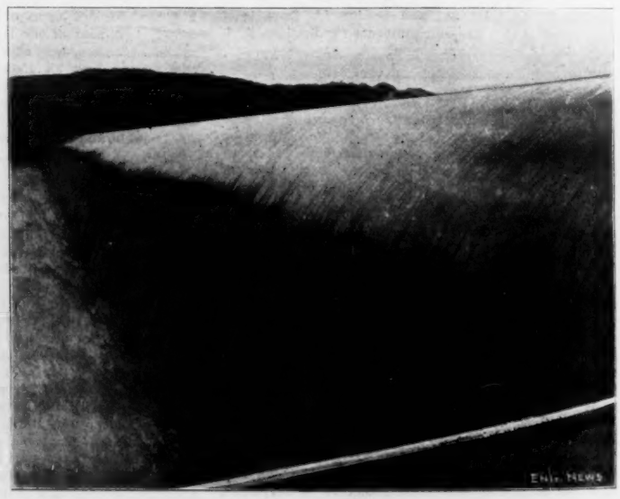

Fig. 3.—Flood Flow, 9¼ ft. on Crest, June 7, 1899.

FIGS. 2 AND 3.—VIEWS OF DAM AT LOW AND HIGH WATER, TAKEN FROM POWER HOUSE.

*Figs. 1, 2, 3, 6 and 11 are from views sent by Mr. Chance; Fig. 4, the sketch plan, and the views, Figs. 5, 8, 9 and 12 are from Prof. Taylor; Figs. 7 and 10 were reproduced from views taken by Mr. Roome. The views sent by Prof. Taylor, except Fig. 5, were photographed by Mr. Journeay, and those sent by Mr. Chance were taken by Mr. S. B. Hill, both photographers of Austin, Tex.

*Professor of Civil Engineering in the University of Texas, Austin, Tex. Report dated April 12, 1900.

lake level was 9.8 ft. above the dam crest. (Fig. 3 shows this flood, earlier in the same day, at the 9.25-ft. level.—Ed.)

At 11:20 a. m., April 7, when the lake level had reached a height above the dam crest of 11.07 ft., the dam gave way at B, Figs. 4 and 5, about 300 ft. from east end of dam. Observers at E, F, and H all unite in their testimony that it first opened at B, as if the mad current had simply pushed its way through the structure. Sooner than it takes to write these words, the two sections AB and BC, each about 250 ft. long, were shoved or pushed into the positions A′B′ and B′C′, about 60 ft. from their former position in the dam. There was not the slightest overturning. After the warning break at B, the water over the part ABC was seen to rise several feet, and the

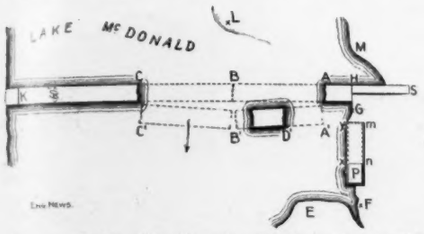

Fig. 4.—Sketch Plan Showing Break in the Austin Dam, April 7, 1900.

By Prof. T. U. Taylor, Assoc. M. Am. Soc. C. E.

next instant the pent-up water was pouring over the sections A′B′ and B′C′. The view, Fig. 5, was taken at 11:23 a. m., or three minutes after the failure. The parts may be identified by comparing Fig. 5 with the sketch plan, Fig. 4, the view extending slightly beyond C. At 11:30 a. m. the lake level fell to the crest of the dam, and the two sections A′B′ and B′C′ were seen to be upright, each still a solid mass, complete, unbroken, and intact (except for the scaling off of the granite facing from the down-stream face), occupying a position practically parallel to the dam. To the casual observer, the detached portions at this time had the appearance of having been erected in their new positions by the original contractor. The crests of A′B′ and B′C′ were about on the same level with their original position, except at C′, which was slightly higher, giving B′C′ a slight longitudinal dip towards the power house. Measuring along the crest, the break left about 500 ft. of the dam, KC, at the west end and 83 ft., AH, at the east end still standing unaffected.

As soon as the sections were broken out and moved to the positions A′B′ and B′C′, the partially pent-up waters rushed through the gap, and that part held back by CK produced a strong current in the direction of the power house. The current struck the power house wall almost on a level with the pump-room floor (about 12 ft. below the crest of the dam), crushed in all the windows on the west side, flooded all the lower stories, and caught and drowned five employees and three small boys. Two of the employees miraculously escaped by climbing through a belt hole in the dynamo room, x y m n, Fig. 4. These workmen were pumping water from the lower portions of the power house.

At 12 o'clock, 40 minutes after the break, the broken section B′C′ turned over towards the dam and disappeared beneath the torrent, and the eastern end of the section A′B′ was broken up and engulfed. This left about 100 ft., B′D′, which was shifted slightly out of its parallel position. This section, B′D′, was cracked from the crest as far down as could be seen. Sometime during Saturday night the smallest portion of this 100-ft. section was swept away. Figs. 8, 9 and 12 show views taken April 8 by Journeay, of Austin, from positions G, F and L, respectively, of Fig. 4.

At 12:05 a. m. Sunday, April 8, the northern two-thirds, x y m n, of the west wall of the power house gave way and fell, taking with it that part of the roof over the dynamo floor, and badly wrecking the corresponding part of the east wall. The power house was 198 × 54 ft., and had a total height on the river side of 112 ft. The walls were built of brick, except the first 20 ft., which was constructed of dressed granite blocks about 2½ × 5 × 3 ft. The dynamo floor, x y m n, was about on a level with the crest of the dam. The floor of this room continued in a railing (as a gallery?—Ed.) over the pump floor (P), upon which the big duplex pumps were located.

It is too early at this writing to tell whether any of the foundation courses of the 500-ft. gap in the dam has been washed away; but the fact that the crest of the detached sections, when they settled down in their first positions, C′A′B′, Fig. 4, was almost level with the crest of the remaining portions, indicates that very little if any of the foundation remains.

The Water and Light Commission, which has charge of the dam and the water and light plant owned by the city, is of the opinion that the dam should be rebuilt upon safer plans; that the head-gate masonry be secured against leaks, and that the penstocks be lowered. It has appointed committees of leading citizens to consider ways and means. These committees will report to a mass meeting on Saturday, April 14.

The Commission has already ordered two 250-HP. steam engines to operate the pumps at the lower station, near the filtering ditches, two miles below the dam.

The old water company (The Austin Water, Light & Power Co.—Ed.) has offered to purchase at current prices and operate all of the city's water pipes and connections and electric light system.

Historical Note.—The people of Austin, by a vote of 27 to 1, on May 5, 1890, authorized the issuance of bonds to the amount of $1,400,000 for the erection of a dam, power house, the laying the necessary pipe, the construction of a filter gallery and reservoir and complete water and light plant. The aggregate cost of these enterprises was estimated by Mr. Joseph P. Frizell, M. Am. Soc. C. E., to be $1,363,000.

On June 24, 1895, the city by vote authorized the issuance of $200,000 additional water and light bonds.

The total amount paid Mr. Corrigan on account of the dam and the head-gate masonry was $608,000. The canal was abandoned, after about $20,000 had been spent upon it, in favor of the big 9-ft. penstocks. The reservoir was never built. (The construction of the filter gallery was postponed. The total expenditures to Nov. 30, 1895, including various changes, but without the reservoir and filter gallery, was $1,391,000, with $56,000 due contractors.—Ed.)

It was at first contemplated to erect the power house several hundred feet away from the dam; but the authorities finally decided to erect it in the position shown in Fig. 4. A foundation was cut out of the limestone rock into which the east end of the dam projected. The power house was to rest on the top of this shelf, the level of which was slightly below the crest of dam. In the latter part of May, 1893 (not over two weeks after the water first flowed over its crest), a leak developed under the bulkhead masonry and discharged through the vertical face of the proposed power house foundation at a point about 40 ft. below the crest of the dam. Within a few hours this proposed foundation was an utter ruin and two-thirds of the bulkhead broke about 40 ft. from the east end of the dam. In round numbers this leak cost the city $97,000. (See Engineering News, Feb. 22, 1900.)

The power house was equipped with two big duplex pumps, with dynamos, regulators, turbines, etc., for supplying the city with water and light, the Rapid Transit and Dam and Suburban Railway with power; and for furnishing power to printing presses, planers, etc., to the extent of 200-HP. The total average horse power for the last two years has been about 800, but the load was too big to carry, as the lake level repeatedly sank as much as 10 ft. below the crest.

For the last two years the city has been constructing filtering trenches in the sand beds about two miles below the dam. At the time of the accident these had just been finished and put into operation.

Account of the Failure by H. M. Chance, M. Am. Inst. M. E., dated Austin, April 8.

Rain had been falling in the area drained by the Colorado River for two or three days, but early on Saturday morning, April 7, between the hours of 2 and 4 o'clock, an enormous precipitation occurred over that part of the drainage basin in the vicinity of Austin and extending up the river for many miles, flooding the country and causing all the smaller streams to overflow their banks.

The river at Austin rose 10 or 12 ft. in about an hour, about 7 a. m., and the water continued to rise steady until about 10:30 or 11 o'clock, at which time there was 8 or 10 ft. of water passing over the top of the dam.

At the time the break occurred the writer was examining the conditions present at the water-works plant of the Austin Water, Light & Power Co. (a rival to the city plant) on the bank of the river two miles below the dam

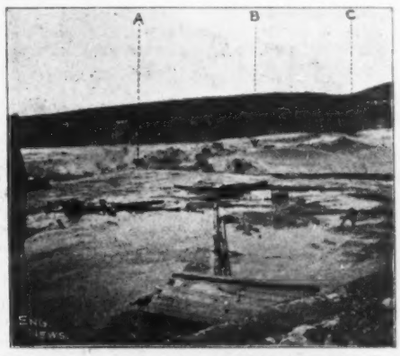

Fig. 5.—View of Break from East End, Looking Down Stream, Three Minutes After Failure.

and his attention was attracted by hearing people shout-bridges and buildings located near the banks.

Looking up the river, a turbulent wave of water, 6 or 8 ft. high, was seen coming rapidly down-stream. The river was already very high and threatening great damage to bridges and beildings located near the banks.

It was at once evident that the dam two miles above had failed. Having a team at hand, the writer drove at once to the dam, arriving there probably 20 minutes after the break occurred.

At that time two large fragments of the dam remained intact, standing nearly horizontal, but moved down stream about 30 to 50 ft. These pieces were each about 100 ft. long. About 500 ft. of the dam had disappeared, the break occurring about 50 ft. from the eastern shore (83 ft., according to Prof. Taylor's report.—Ed.). The position of these fragments, marked (see Prof. Taylor's sketch, Fig. 4.—Ed.) A′B′ and B′ C′, still standing nearly horizontal and upright, appears to indicate that the cause of failure was a sliding out bodily on its base of the portion that failed. Three pieces, c,d,e, (at points A′,B′,C′.—Ed.) had disappeared. Eye-witnesses stated to me that one or two pieces rolled over into deep water and disappeared at the time of the break.

About 20 minutes after my arrival fragment B′C′ slid off and rolled over into deep water and was hidden from view, fragment A′B′ remaining in place during most of

FIG. 6.—VIEW OF BREAK FROM HEAD-GATES, ABOUT ONE HOUR AFTER THE FAILURE.

the afternoon. Towards night this began to break up, and by Sunday morning only a small piece of this fragment, 15 or 20 ft. long, remained in sight.

During the night the walls, or rather the outside wall, of the power house collapsed, burying beneath it the electrical equipment.

Fortunately for the community inhabitating the valley below the dam during the six years that have elapsed since it was built, the lake has rapidly been filling up with mud and sand. This had filled in at the dam until there was a depth of less than 15 or 20 ft. of water at the dam and the quantity of water escaping was limited to what could flow over this mud filling. This filling (see views, especially Figs. 7, 9 and 12.—Ed.) gradually was cut back by the water until by the next morning but little of it remained near the dam, but it served a useful purpose in retarding the escape of the water, distributing over 10 or 12 hours a volume that otherwise would have run out in an almost irresistible flood.

The dam was of rubble masonry, with cut granite faces. The masonry appears well built for work of its class.

The city is without water, light or power, the pumps of the old company's plant being submerged, but they will probably be started as soon as the water subsides, as this plant appears to have been damaged very little.

The City of Austin built the dam to furnish water, light and electric power, it being estimated that with the storage afforded by the dam there would be a surplus of perhaps 8,000 or 10,000 HP. that could be sold for manufacturing purposes. These expectations were not realized. During 4 or 5 months of the year there has barely been sufficient power to operate the pumps, and very little available for light and power, so that the city was contemplating adding an auxiliary steam plant.

The competition between the city and the old company in the water service has given consumers two pipe systems over nearly the whole city and water rates at less than the cost of the service.

Account of Mr. A. B. Roome.

I arrived at the power house very shortly after the break in the dam occurred, and obtained statements from several eye-witnesses, which seemed to be corroborated by the position of the masonry and the flow of the water. It is evident that the dam did not give way at the top first, or topple over; but the two sections were displaced bodily and forced down stream about 40 ft. Forty-five minutes afterwards these sections broke and disappeared, except for about 50 ft. of the one nearest the power house, which remained in a perfectly upright position with its top only a few feet below its original height. About 100 yds. below the dam the water rose to a height of 25 ft. or more, and this with the depression immediately above was probably caused by the masonry lodging at this point.

Some time after the dam gave way the direction of the flow through the parts which remained standing was considerably changed, and it was quite apparent that the displaced section which remained in an upright position was directing the water against the power house foundation, and that unless it could be blown up or removed in some other way the power house would probably collapse.

The heart of the dam seemed to be in good condition, and the cause of the failure at the time of the break appeared to be due to the foundations and faults in the limestone bottom. The immense amount of silt which had accumulated in Lake McDonald was very forcibly emphasized by the very disagreeable odor which hung over the city after the break.

The flood resulting from the break in the dam pushed in the up-stream wall of the pump room of the old Austin Light & Power Co. and so crippled this plant as to leave the city without any water for fire or domestic purposes, except that contained in a few cisterns. All precautions that were possible under the circumstances were taken to protect the city against fire, and neighboring towns furnished chemical engines and a steam fire-engine.

Accounts of Several Eye-Witnesses.

Of the numerous descriptions of the break ascribed to eye-witnesses, the following, condensed from a press despatch dated April 8, or the next day after the failure, is by all odds the most circumstantial and picturesque, it being the account of Mr. Jefferson McLemore:

I was gazing intently at the great body of water as it swept gracefully over the crest of the dam, carrying with it acres of drift that parted as it went down the falls. The water over the crest was more than 10 ft. in depth, and was rising at the rate of 18 ins. an hour. The fall of the water was about 40 ft., and the roaring and surging that it produced can be better imagined than described. It was grand and awe-inspiring, and nothing in my opinion could in any measure compare with it, except the falls of Niagara.

While thus gazing with awe on a sight such as I had never before witnessed, I noticed a sudden commotion of the waters near the center of the dam. For a moment the water where the commotion occurred seemed to recede, but it was only for a moment. It then shot upward in a tremendous spout to a height of perhaps 50 ft. as if in gleeful fury, and I saw that the dam was giving way. The commotion spread toward the east end of the dam, and there was a trembling of the earth. The mighty waters roared and plunged with an indescribable fury, and the river, which a moment before had presented a scene of graceful grandeur as it curved over the dam, was turned into a seething maelstrom, so awful and so terrible that nothing save the pen of a Dante or a Byron could do it justice.

I was appalled and entranced. My feelings were such as I had never before and never again hope to experience. Suddenly above the dismal roar of the surging raging waters there came a cry. "The dam is breaking, the dam is breaking." The sound of the cry was as dismal as that of the maelstrom, and people shuddered and their blood seemed chilled, although the sun shone warmly from a cloudless sky. When the break occurred the distance from the crest of the wave as it rolled over the dam to the water below was about 40 ft. Imagine, then, if you can a body of water 40 ft. in height and of great width and length suddenly released from confinement, and you will have a faint idea of the scene that I witnessed at the great dam across the Colorado River yesterday morning, a few minutes before 11 o'clock. It was a scene that beggars all description, and as the waters plunged and roared and seethed and foamed they seemed to laugh in utter scorn at the futile attempts of man to bridle them.

When the break occurred seven men and two boys were at work in the lower story (of the power house.—Ed.), and the first intimation they had that danger was near was by the rush of water into the building. One of the men rose with the deluge and by a lucky chance struck an opening, through which he made his escape, being pulled from the water more dead than alive. Another was caught by a water spout produced by the rush of waters into the building and shot up through another opening, and he, too, was saved, as if by a miracle. The others were caught in a death trap and perished in the room where they were at work.

When the dam gave way the great tidal wave swept around the south end of the power house, where the doors and windows are lower than at any other portion of the building. It was through these doors and windows that the water rushed in, and in less time than it takes to write it the two lower stories of the building were submerged.

The water swirled around the building and then subsided almost as suddenly as it came. * * *

During all of this time the water, slightly turned by a high point of land that jutted out into the stream just south of the dam, shrieked and howled as though it were maddened because the least obstruction dared stand in its way. In a few minutes after the break occurred the

FIG. 7.—VIEW OF BREAK FROM ABOVE, ABOUT TWO HOURS AFTER FAILURE.

FIG. 10.—VIEW TAKEN ABOUT TWO HOURS AFTER THE FAILURE, SHOWING POWER HOUSE INTACT.

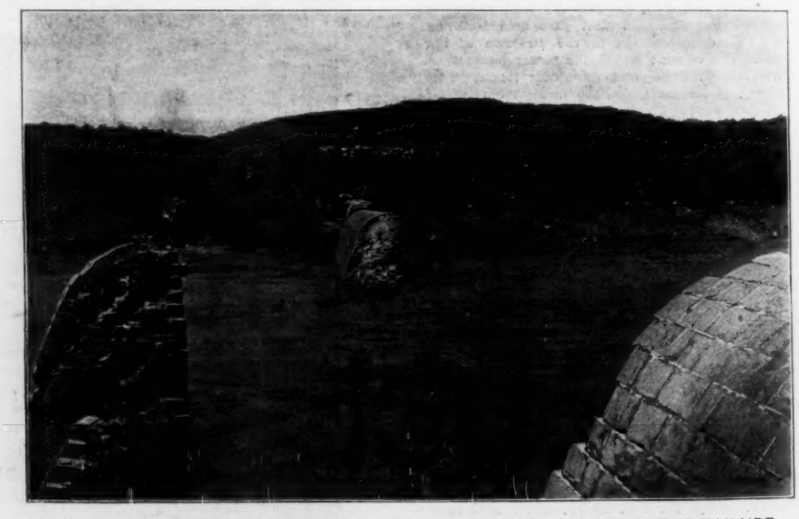

FIG. 8.—VIEW OF BREAK FROM POINT G, FIG. 4, THE NEXT DAY AFTER THE FAILURE.

water above the dam sought its level with that below. Great breakers lashed each other in maddened fury, and huge logs of drift wood were whirled and tossed about as though they had been straws. A portion of the large boat house just above the dam fell with a crash, and the timbers, floating down, were dashed to pieces and disappeared in the maelstrom, only to come to the surface again at some point quite a distance away.

Once released from its confinement the water subsided rapidly, seeking a level with that below the dam, and

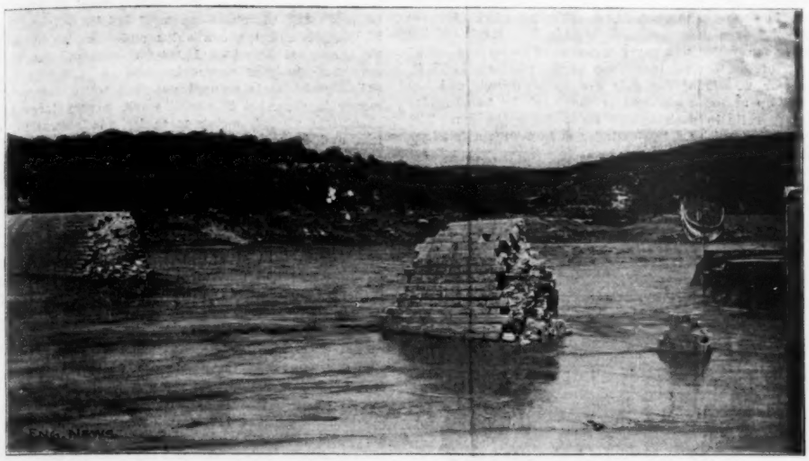

FIG. 9.—VIEW OF BREAK FROM POINT F, FIG. 4, THE DAY FOLLOWING THE FAILURE.

then it was seen how the break had occurred. The dam was not toppled over, as many supposed it would be, but instead a large section, beginning near the center and extending toward the east bank, was moved bodily down the stream a distance of at least 40 ft. Another section, extending to within 30 ft. of the head-gate masonry on the east end, was also moved down stream a distance of 40 or 50 ft. Between these two displaced sections there was a gap of about 100 ft. where the dam had completely disappeared, and it was not long before the section nearest the center also crumbled and disappeared. Had the remaining displaced section also tumbled down, the power house, which went down a few hours later, would probably have been saved. As it was, this section threw a heavy current against the power house, which eventually undermined the west wall of the building and caused it to collapse.

We also condense, from the Austin "Tribune," the story of two other eye-witnesses, stationed at different points, as showing, with the preceding account, and with those in our special reports, the general unanimity of opinion as to just how the break appeared. Mr. Neil Begley said that he was standing on the penstocks, when:

I heard a dull thud, something like a pile-driver makes when driving a pile into the ground. I saw the water spread out and everything seemed to go down at once. Then it appeared as if a tidal wave had suddenly come rushing down the river. * * * When I first noticed the break it seemed as if a wave of water in a semicircle about 10 ft. high had suddenly come rushing down the river towards the dam, and it looked as if the dam spread out by the terrible force with which the raging waters struck the side of the dam, and the center of the structure gave way and the tidal wave rushed on both sides of the embankment. Then the power house was struck and water soon filled the lower floors of that structure.

Mr. Frank Jones thus describes what he saw:

I was standing with a number of people on a high embankment south of the power house, watching the dam about 11 o'clock. Some of the party were engaged in taking views of the dam with cameras. All of a sudden the dam broke in the middle and there was a great rush of water. The embankment on which we were standing trembled and in a few moments the water was on us.

Letter from Mr. J. P. Frizell, M. Am. Soc. C. E., Dated Boston, April 14, 1900.

So far as any sense of responsibility for the late deplorable accident at Austin is concerned, I don't feel called on to say anything, having, as I think, sufficiently washed my hands of that responsibility. The following letter speaks for itself:

Austin, Tex., June 29, 1892.

To the Hon. Board of Public Works of the City of Austin.

Gentlemen: Some six months ago I had the misfortune to offend the chairman of the Board by insisting that his son, then employed on the work, should perform the duty for which he was paid. An altercation arose which resulted in the young man's name being dropped from the roll.

Since that time the chairman has made it the chief business of his life to embarrass and obstruct the engineer. This disposition first manifested itself in hypercritical charges of remissness on the part of the engineer, and in endless suggestions of changes in the plans, which secured no attention from the board. He then took the draftsman of the office under his own personal direction; broke up the engineer office in town; thrust the engineer and his other assistants into a wretched little shanty at the dam; established an engineer office of his own; and took upon himself the functions of engineer of the works, conducting surveys, preparing plans, specifications and contracts, and otherwise acting as engineer of the board. My reason for not sooner taking the action herein indicated is that I had signed an explicit contract with the city, binding myself to design and execute all the several works proposed to be built, the city binding itself, with certain reservations, to continue me in the position of engineer until the completion of the said works. I did not feel at liberty to disregard such a contract upon any light and trivial grounds. The above-described acts, however, are such gross and flagrant violations of the contract, that I no longer feel under any obligation to observe it.

I find myself, moreover, placed in a position in which further connection with the work would be degrading and inconsistent with decent self-respect. I accordingly announce my intention of withdrawing from the position of engineer of the board at the end of the present month.

Very respectfully, Jos. P. Frizell.

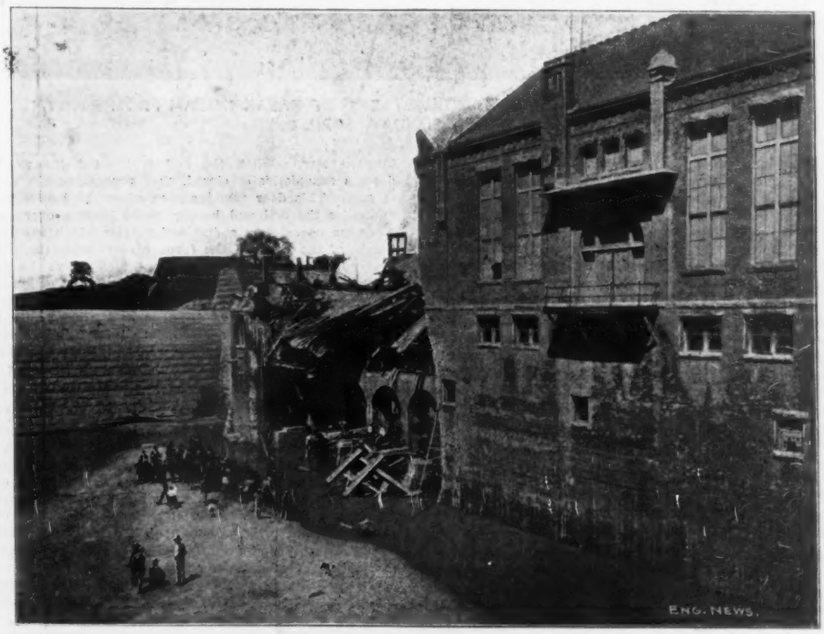

FIG. 11.—WRECKED POWER HOUSE FROM BELOW DAM, TAKEN SUNDAY, APRIL 8.
(The power house failed about 13 hours after the dam broke.)

I append the following letter of later date:

60 Congress St., Boston, April 8, 1896.

Louis Hancock, Mayor, Austin, Tex.

Dear Sir: In laying the foundation of the dam at Austin, a very friable foundation of rock was met with some 300 or 400 ft. from the easterly end. In fact, the rock was poor for the entire easterly half of the river.

I was apprehensive that dangerous abrasion might occur here in future, but as this part, at that time, was overhung by a bank of earth 40 or 50 ft. high, my plan was, to wait till the bank had disappeared, as it might be expected to do on completion of the dam, and then to execute some supplementary work of protection, which would have been easy to do if the work of development contemplated by me had been carried out. The method adopted of placing the power house immediately below the dam and discharging the water along the toe, greatly increases this danger and makes remedial measures much more difficult of application.

My purpose in writing is, to suggest that you cause soundings to be made along the toe of the dam to ascertain if dangerous abrasion is in progress in that locality.

Trusting that you will pardon the liberty I take in offering this suggestion, I am, Very truly yours,

Jos. P. Frizell.

This letter will be intelligible from a glance at the general plan in your last issue, where it will be seen that the discharge from the power house must pass along the toe of the dam some 600 ft. or more to reach the river in low water, with a dangerous tendency to destroy the footing at the toe of the dam, and facilitate a sliding tendency. The supplementary work of protection contemplated above was a heavy bed of concrete footed into the rock, rising to the level of low water at the toe, and sloping down stream. Yours very truly,

Jos. P. Frizell.

Letter from Mr. J. T. Fanning, M. Am. Soc. C. E., Dated Minneapolis, Minn., April 13, 1900.

I have not yet received sufficiently accurate information to enable me to judge to a certainty of the cause of the break in the dam. Some accounts indicate that there was a sliding of a portion of the dam on its base and some indicate that a portion of the dam was undermined by a current which had found its way under the rock of the river bed on which the dam rested. In that part of Texas the lime rock is still in process of crystallization and has a moderately hard, flakey shell where exposed, but is comparatively soft within the thin surface shell, and this shell shows long cracks at intervals. The accounts lead to the impression that a portion of the soft rock under the shell on which the dam rested was washed from beneath the dam by an undercurrent from the upper side; that a vertical crack in the dam resulted from settlement and that then a lifting pressure from a scoured chamber under the dam aided the horizontal pressure of the flood in moving a section of the dam down stream bodily, in an upright position.

The accounts indicate, also, that one end of the displaced section of the dam rested in such a position as to deflect a heavy current against the river wall of the power house, that stood near the dam, and that the power house wall withstood this current 15 hours, after the break in the dam, before failing.

Yours very truly, J. T. Fanning.

Letter from Emile Geyelin, Hydraulic Engineer, Dated Philadelphia, April 14, 1900.

Regarding the Austin Dam failure, I can but express my deepest sympathy for the good people of Austin. In their generous, whole-souled way, they meant to have the best mode as to engineering and material at their pet works. Time has shown some omission, namely, the one of not having waste gates towards the bottom part of the dam, which omission should by all means be rectified whenever the repairs are made on the existing dam.

Regarding the destruction of the pump house and electric house, assuming that I am correctly informed, I have to say that in my report to the commissioners at the time of constructing the dam, I suggested the placing of a building for the pump house 100 ft. or more away from the dam; in which case, had it been done, it is likely the injury would not have been so great as it was.

Yours very truly, Emile Geyelin.

THE INTERNATIONAL CONGRESS OF NAVIGATION may receive an official invitation from the United States Government to hold its ninth session in Washington, D. C., according to the terms of Senate Bill 2330, just passed by that body. Amendments to the original bill appropriate $30,000, instead of $25,000, for the purpose, and the Secretary of State is ordered to prepare suitable halls and rooms for the meeting. The bill has yet to pass the House.

THE LACK OF NAVAL OFFICERS, for the new ships being added to our navy, is again being impressed upon Congress. The President has recommended that each Senator be allowed to appoint a cadet to the Naval Academy, and that the present course be shortened from six to four years. As showing the shortness in officers, the recently commissioned "Kearsarge" has only 13 line and engineer officers, while battleships of the same class in foreign navies have from 23 to 31 officers. More officers are wanted, both on shore and afloat; and the conditions are constantly growing worse.

A CABLE TO HAWAII is recommended by the U. S. Senate, and that body appropriates $3,000,000 for its construction. This Pacific Cable Bill provides that the work shall be done under the supervision of the Navy Department; either by naval vessels fitted for the purpose, or by contract. All materials and appurtenances shall be of American manufacture; provided, they can be procured at a cost not exceeding 12% above the prices in foreign markets. The bill only provides for a cable from San Francisco to Honolulu; to be laid as an experiment; and to decide the future course of the government.

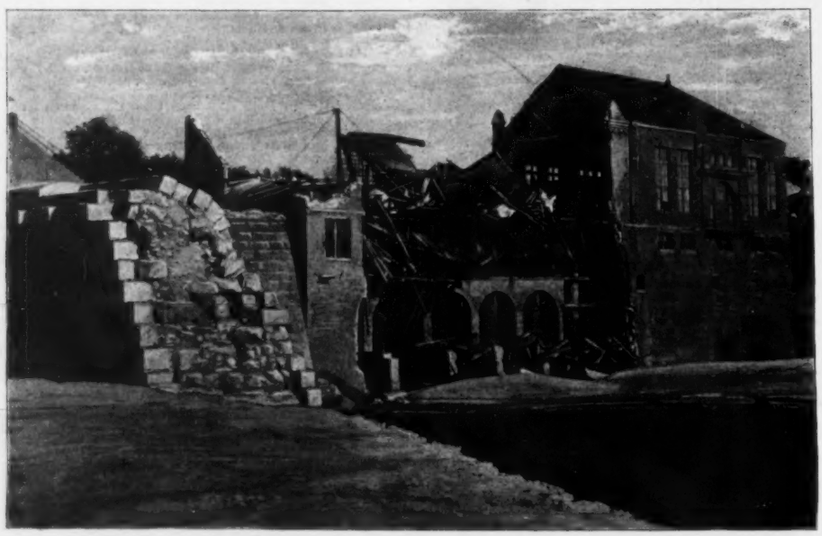

FIG. 12.—WRECKED POWER HOUSE AND EAST END OF BREAK IN DAM FROM POINT L, FIG. 4, TAKEN SUNDAY, APRIL 8.

MARCH EXPORTS, says the U. S. Bureau of Statistics, double the average for March in the decade ending 1896. The total for March, 1900, is $134,313,348; as compared with $75,574,185 in March, 1896, and $66,516,571 in March, 1893. The total exports for the nine months ending March, 1900, is $1,053,832,675; showing that the exports have doubled in 15 years and increased over 53% since 1896. The exports of manufactured articles show an increase over the nine months of the preceding year of $61,000,000. It is expected that the fiscal year 1900 will show exports of $1,300,000,000, and that manufactures will represent fully $400,000,000 of this amount.

THE PARIS EXPOSITION was officially opened on April 14 by President Loubet, though the buildings are in an unfinished condition. The American sections are finished as to buildings, but many of the exhibits are still unpacked. The list of exhibitors shows America next to France, as follows: France, 30,000; United States, 6,564; Belgium, 2,500; Germany, 2,000; Italy, 2,000; Russia, 1,500; Scandinavia, 1,400; Austria, 1,000; Great Britain, 600; English colonies, 600.

IRON MELTED IN FIVE SECONDS is said to have been the result of an experiment conducted on April 7, at the laboratory of Thos. A. Edison, at Orange, N. J. Mr. Louis Dreyfus, representing the Goldschmidt Chemische-Thermo Industrie, of Essen, Germany, conducted the experiment. He placed in a crucible a chemical of unknown composition and covered it with a small quantity of powdered aluminum. In this he placed an iron wrench, ½-in. thick and 6 ins. long, and then lighted the compound. The wrench melted in 5 seconds; and it was estimated that the heat evolved was 3,000° C. The process is supposed to be useful in welding rails and pipes.

A FURNACE HOIST AND STOCK DISTRIBUTOR is described in a recent issue of the "Iron Age," which embodies many new features. It has been installed at the plant of the Stewart Iron Co. at Sharon, Pa., by the Brown Hoisting & Conveying Co., of Cleveland, O. The apparatus is automatic in operation and dispenses entirely with the employment of top fillers. An inclined bridge reaches from the floor of the stock house to the top of the furnace shell and over the furnace. On this is a track for the skip or car, which will carry a charge of three tons. The height of the furnace to the top of the platform is 78 ft. The rear wheels of the skip are double tread, and are picked up at the upper end of the track by two supplementary rails in such a way as to dump the car. The latter is hoisted by a two-cylinder engine with a friction-clutch drum and is lowered by a foot-brake without reversing the engine. The top hopper is covered by a conical structure, which, besides an opening 4 ft. square, is equipped with explosion doors. It rests upon the top ring of the furnace and covers the bell and hopper. Overwinding of the hoisting engine is prevented by a safety throttle-valve. When the bell is lowered the gas-seal door is automatically closed, thus preventing the escape of gas. This door remains open when the bell is up as otherwise the bell and hopper would become overheated. Near the operator is a dial and pointer which shows the height of the stock in the furnace every time the bell is lowered. There is also a register which shows the number of cars charged into the hopper before the lowering of the bell. An auxiliary hopper is so arranged as to insure any desired order of distribution of stock in the furnace. This distributor is supported on roller-bearings. At each trip of the skip the distributing cone is revolved through part of a revolution. An oval spout at the bottom of the cone deposits the load in the desired portion of the regular hopper.

A CEMENT FLOORING FOR CARS is now being introduced by the Pullman Co., under the trade name of "Monolith," and is being used on the floors of the company's cars as well as on a great many passenger cars of different roads. The material is furnished by the company, which owns the patents upon it. Mr. T. H. Wickes, Vice-President of the Pullman Co., Chicago, informs us that it is a plaster composition of sawdust mixed with a specially prepared liquid and cement. Coloring matter can be introduced when the composition is being mixed. It is laid with a trowel to a thickness of about ½-in., and when dry it is dustproof, impervious to water, presents an even surface and is readily cleaned. It is very light in weight. Mr. J. H. McConnell, Superintendent of Motive Power and Machinery, of the Union Pacific Ry., informs us that he has a number of passenger, mail, baggage, dining and composite cars whose floors are covered with this preparation.

THE BRICK STREET PAVEMENTS of Albany, N. Y., have called out an adverse message from Mayor Blessing. These pavements are laid on concrete foundations, and the trouble complained of is caused by breaks in the sewers or water mains undermining the pavement and letting down large sections which are expensive to repair. It seems that in some cases the pavement was laid immediately over a newly-built sewer and before the back-filling had time to settle. It is plain that similar objection could be made to any class of pavement subjected to the same conditions, and it hardly seems fair to lay the blame on brick pavements.

THE PUBLIC HIGHWAYS, STREETS AND BRIDGES of the Province of Ontario, Canada, says the Provincial Instructor on Public Highways, have had expended upon them, in the ten years 1887-1896, a total of $30,622,995. Of this total, the cities expended $14,483,643; the towns, $6,759,626, and the townships and counties, $9,380,050. To this must be added 11,000,000 days of statute labor expended in the townships, or a labor value of $41,623,958. It is pointed out that while much of this money is expended in useful work, a very large part is absolutely wasted, owing to faulty administration, careless and inexperienced supervision and improper influences effecting the character of the methods employed. The Instructor advocates a system of money tax as a substitution for statute labor, as the latter usually results in temporary and perishable work. He points out that the cities should assist in making the country roads; for if we contrast an 80-acre farm with a 50-ft. town lot, and a farm road at $1,000 with a city street at $5,280 per mile, we find that the cost to the individual farmer is $125, as compared with $25 for the city property owner. Though city streets often cost more than this sum, so do the country roads.

THE PETRIFIED FOREST OF ARIZONA may be included in a National Park by action of Congress. This forest, which possesses extraordinary geologic and scenic interest, is included in an area ten miles square in the northwest part of Apache Co., Arizona, with the nearest railway station only a few miles off, at Adamawa, on the Santa Fe R. R. In this region, cut up by canyons and ravines, are thousands of silicified tree trunks and fragments of trees, mingling with the red, brown, white and purple of the sandstone formation. In one place a petrified tree trunk spans a ravine nearly 50 ft. wide, and forms a foot bridge. Prof. Lester F. Ward, paleontologist of the Smithsonian, dates this forest back to the Triassic, or early part of the Mesozoic period. The trees are supposed to have been once washed down to an ocean bed that has since been elevated 6,000 to 7,000 ft. above the sea.

THE NEW YORK ZOOLOGICAL GARDEN, in Bronx Park, and authority to spend $300,000 in its further development, under the bill recently signed by Governor Roosevelt. The appropriation of $300,000 is left to the discretion of the Board of Estimates and Appropriations, and is conditioned upon the Zoological Society raising and expending $200,000. The society has already spent $175,000 and is now raising the other $25,000.

BUILDING THE RONCO TUNNEL, NEAR GENOA, ITALY

(With full-page plate.)

The Ronco tunnel is 5.53 miles long, and is located between Ponterosso and Scrivia, on the system of railways leading to Genoa. The line previously followed the valley of the Scrivia and passed under the crest of the watershed by the shorter tunnel of Giovi. The difference in elevation between the two ends of the Ronco tunnel is 96.27 m., says "Le Genie Civil," in describing this work, and the grade descends continuously towards Genoa. The attack was made from the two ends and six intermediate shafts, simultaneously; the rock was an argillaceous schist in beds almost parallel to the axis of the tunnel; an unfavorable condition for safe excavation. This schist disintegrated rapidly under atmospheric influences, and the temperature in the tunnel was high. Within a couple of weeks after exposure this ground began to swell, and it became as soft as dough; the shock of the blasts, the absorption of water from the Brandt drills used and the movement resulting from the placing and shifting of the timbering all added to the difficulties encountered and aided in destroying the equilibrium of the soil penetrated.

The advance heading, of small section, was first driven for the entire length of the tunnel; but as soon as an attempt was made to enlarge to the final section, trouble began. The original section adopted gave way to the weight imposed and to the movement of the soil, and cracked in many places, and in others was very much deformed.

It became necessary to adopt a new section and to rebuild the destroyed masonry; and this work had to be done as rapidly as possible and before the soil had time to move. The following method was then adopted, as shown in Figs. 1 to 10: The

old masonry lining was first supported by strong timbering, and an excavation was then made at the key, and enlarged progressively towards the right and left to provide room for the new tunnel section adopted. During the enlargement the soil was held up by radiating timbers resting upon the temporary central falseworks; but as the work progressed this latter was replaced by a definite system of timbers supported at the level of the rails. The masonry walls and their foundations were built as rapidly as possible, to the spring of the arch, and the arch was built of brick; after the arch was finished the space below the rail-level was excavated, and the reverse-arch, of brick, was put into place.

The enlargement of the existing advance heading required careful work. A transverse gallery was first dug, and at the end of this a trench was made for the foundations of the sidewalls. The masonry was built in this trench up to the spring of the arch, and the same series of operations secured the foundation and the opposite sidewall. The space between these sidewalls and the central gallery was then filled up, after having built against the finished masonry a little dry wall of bricks and sand. Then only did the workmen commence to excavate above the central gallery and to put in the centers for the arch. These centers were partly sustained by the sidewalls, as shown. This lining was built in sections of from 20 to 26 ft. in length, though there were frequent delays from the inevitable settlement of the material following the striking of the centers. The work here described consumed 23 months of time; and some idea of the volume of work performed can be had when it it realized that the material excavated amounted to 220,080 cu. yds., and the new masonry to 153,557 cu. yds.

Every precaution was taken to ventilate the workings, as the air was very much vitiated, especially by the rapid rotting of the timbers under a temperature as high as 30° C., or 86° Fahr., and sometimes touching 93° Fahr. At the higher temperatures the men only worked for two consecutive hours. Two ventilating fans were established at the south end of the tunnel, with diameters of 5.9 and 3.6 ft., respectively, and making 1,200 to 3,000 revolutions per minute; these were driven by a 60-HP. Sulzer engine. At the bottom of Shaft No. 1 were installed two air compressors, run by two 50-HP. engines and compressing air to 3 atmospheres; two other compressors were placed at Shaft No. 3, to provide compressed air.

The new masonry section adopted was based upon a careful study of the forces which destroyed the old masonry, and especially that of the wood used in the timbering. It was found that the pressure exerted by the ground upon the lining masonry varied from 15.2 to 6 tons per sq. ft. It was also found that sound oak, before it was put into the tunnel, would withstand a breaking load, by buckling, of 570 kg. per cm²; while the same wood, after some months of service, was only good for 270 kg. Crushing tests for new oak gave limiting loads of 330 to 250 kg. per cm²; but, after use, these were reduced to 225 and 130 kg. per cm². The mathematical calculations for the thickness of the lining are given in full in "Le Genie Civil," for Feb. 17, 1900, and to that journal we are indebted for the data and cuts here used.

A 175-FT. COUNTERBALANCED PLATE-GIRDER SWING BRIDGE; CHICAGO, MILWAUKEE & ST. PAUL RY.

(With full-page plate.)

We illustrate in this issue a counterbalanced swing bridge of somewhat notable dimensions and characteristics. This bridge was constructed to carry the single track of the Chicago, Milwaukee & St. Paul Ry., over the Chicago River, near Clybourn Place, in Chicago, and it replaced a wooden swing bridge of 161 ft. span. As shown by Fig. 1, the location of the bridge is at a rather sharp bend in the river, which was in the past one of the most difficult of the many cramped passageways for vessels on this busy stream. In this plan the dotted lines show the location of the old wooden bridge with its cylindrical center pier, and the full lines show the relative location of the new bridge which replaces it. The center pier of the old bridge, it will be noticed, was left undisturbed to form the support pier for the end of the new swing span, and for one end of the short fixed shore span. By moving the center pier of the new swing span inshore, however, and by cutting off the elbow of land forming the bend in the original shore line the waterway for vessels has been made much wider and straighter. The nature of these changes is clearly shown by the drawings, which, with the remaining illustrations and the description, have been abstracted from a paper by Mr. Albert Reichmann in the December, 1899, number of the "Journal of the Western Society of Engineers."

Besides the end-bearing pier previously mentioned, the substructure of the swing span proper consists of a curved abutment carrying the counterbalanced or inshore arm of the span, and of a pier carrying the roller ring on which the bulk of the weight of the bridge is supported. Last there is a small pivot pier proper. The location and nature of all of this masonry is clearly indicated by the plan and elevation shown by Fig. 2. This illustration also shows the general design of the bridge. It is a plate girder swing span 175 ft. 2 ins. long over all, with double-track approaches, which are gauntleted. The distance from the center of rotation to the end of the long arm is 141 ft. 6 ins., and from the same point to the end of the short arm it is 33 ft. 8 ins. From the roller ring to the end of the long arm is 108 ft. The main girders are 9 ft. deep, tapering to 6 ft. deep at the end of the long arm, and they are spaced 14 ft. 2 ins. apart c. to c. The girder flanges are composed of $8 \times 8 \times \frac{3}{4}$-in. angles, and $18 \times \frac{1}{2}$-in. cover plates. The largest flange section consists of seven of these cover plates, or a gross area of 85.2 sq. ins. The bridge is divided into ten panels, with the floor beams, extending from 1 in. below the base of the rails to the bottom of the girders. The stringers are spaced 7 ft. apart. The laterals are

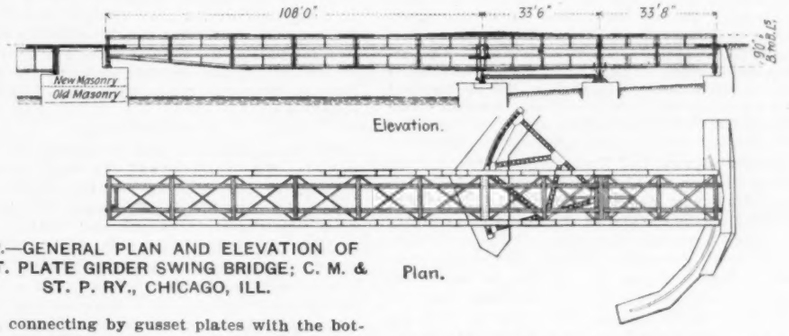

FIG. 2.—GENERAL PLAN AND ELEVATION OF 175-FT. PLATE GIRDER SWING BRIDGE; C. M. & ST. P. RY., CHICAGO, ILL.

angles, connecting by gusset plates with the bottom flanges of the girders and of the floor beams.

As previously stated, almost the entire dead weight of the bridge is carried by a live roller ring. The rollers are 24 in number, 18 ins. in diameter, and 10 ins. face. These rollers are held in place by a triangular frame, which is most clearly shown by Fig. 2. The frame is pivoted to a center casting on the pivot pier in the manner clearly indicated by Fig. 3. As shown by Fig. 4, the weight of the bridge is distributed on the roller ring by means of a large box girder which is stiffened by exterior brackets. The bottom plate of this girder is planed to a bevel to make a track for the rollers. It was 19 ft. 3 ins. long and $1\frac{5}{8}$ ins. thick at the thickest portion. Referring also to Fig. 4, it will be seen that the rollers are held in position on the inside by a circular girder, and on the outside by a $6 \times 4 \times \frac{5}{8}$-in. angle, upon which was placed a rack of the same size as the rack on the tread casting.

The bridge opens through an angle of 57° 7', and in one direction only, as shown by Fig. 1. The roller ring travels with one-half the velocity of the bridge, and in order to keep the bridge in the same relative position to the roller nest, a system of gearing was introduced. One rack was placed on the tread casting of the bridge, and another on the live roller ring, as stated above. One pinion, as will be seen from Fig. 4, meshes into the rack on the tread casting, and another of the same size into the rack of the roller nest. Referring to the drawing, Fig. 5, the motor shaft carries a pinion A gearing into the spur wheel B on the driving shaft C. A pinion D, on the driving shaft just below the spur wheel B, meshes with an idler E, which meshes with the spur wheel F, operating the roller ring driving shaft G. The pinion D, and the idler E, are the same size, which is one-half the size of the spur F. The tread casting is 10 ins. high, with $1\frac{1}{2}$-in. steel plate tread on top, and it is secured to the pier masonry by 1-in. bolts.

The end lifting and locking arrangement is shown by Fig. 3. The end lifting device consists of a roller sector, which has an axle with 1-in. eccentricity, so that when the axle makes a half revolution, the lift raises the bridge 2 ins. The roller sector rests on a cast-bearing plate, which is provided with shim plates, so that its height may be varied. The end lift is operated by a shaft, which runs transversely to the bridge, and which is in turn driven by a longitudinal shaft. It requires $1\frac{1}{2}$ revolutions of the transverse shaft to raise the lift. To this shaft is geared the rail lift, Fig. 5, which is geared in the same ratio as the end lift, and is operated by an eccentric.

Figs. 3 and 5 show clearly the construction at the end of the long arm. The short arm of the span is 67 ft. 2 ins. long, and is weighted down with 113,300 lbs. of cast iron. At this point the advantage of using a cross girder resting on a segmental roller ring becomes apparent. If a complete drum had been employed the effective length of the short arm would have been reduced by nearly the length of the diameter of the drum. The counterweights were rectangular iron castings, and were all placed in a space about 3×3 ft. in plan, and entirely below the floor line. To carry the outer end of the short arm there are two 18-in. diameter rollers running on an 85-lb. circular rail. The weight carried by these rollers is just enough to give a reaction at all times.

The operating machinery is actuated by a 25-HP. electric crane motor, set just in front of the large box girder. As already indicated, the motor shaft pinion engages with a large spur wheel on the main driving shaft. This spur wheel is movable on its shaft axis and has a clutch connection on each end of its hub. When this spur wheel is rotated in one direction, one clutch engages the gearing operating the end lift, and when it is rotated in the other direction the other clutch engages with the gearing operating the turning machinery. The latch is the ordinary spring latch operated by hand.

The plan of erecting the swing span was to set up and rivet the span in the open position. The girders were erected 2 ft. 6 ins. below final grade by omitting the top center casting, live roller ring and triangular spider frame. The plan then was to raise the span into position by jacks and insert the parts of the pivot and drum construction previously omitted, put on the ties and rails, and swing the bridge, the old wooden span having been partly removed to permit of this proceeding. Neither the construction nor the erection of the fixed shore span call for description. The total weight of the swing span was 494,384 lbs., made up as follows: Structural steel, 331,281 lbs.; cast iron, exclusive of counterweight, 30,775 lbs.; counterweight, 113,300 lbs.; cast-steel shafting, etc., 19,028 lbs. The bridge was built by the American Bridge Works, of Chicago, Ill. The detail drawings of all parts, except the electric machinery, which was worked up by G. P. Nichols & Bro., of Chicago, were prepared in the offices of the Bridge and Building Department of the Chicago, Milwaukee & St. Paul Ry., Mr. Onward Bates, M. Am. Soc. C. E., Engineer.

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ADVERTISING RATES: 20 cents a line. Want notices, special rates, see page XXI. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.

The abandonment of the storage battery system of operation on the Chicago & Englewood Electric Ry., which was noted in our last week's issue, probably marks the end of the use in this country of storage batteries as a means of street car propulsion. The attempts to exploit this system have been numerous during the past dozen years, but they have one and all met the same fate that befel the old Julian system, which was tried on the Fourth Avenue road in New York city in the pioneer days of storage batteries.

The fatal obstacle to the success of storage battery cars on street railways is practically the same as that which stands in the way of the compressed air scheme, viz., that the electric trolley system can meet every requirement and do the work at considerably lower cost. If the present electric street railway system had never been developed, there would be a fine field for the profitable introduction of storage battery cars and compressed air cars. As things are, however, the inability of the storage battery system to meet its rival's competition has been practically demonstrated; and there is no reason to believe that the compressed air car stands a better chance of success, save possibly for a limited application under peculiar local conditions, as on the cross-town lines on Manhattan Island.

The delays of justice in the case of the Savannah Harbor contractors, upon which we commented last week, are proposed to be remedied by a bill which has been drafted by Attorney-General Griggs and introduced in Congress. The bill provides, in substance, that a person indicted for infraction of a Federal statute, who is found outside the district where the indictment is brought, may be arrested on a warrant to be issued by any United States Judge or Commissioner upon application of the District Attorney of the district where the indictment is found. In an argument accompanying the bill, the Attorney-General shows that if Judge Brown's decision is a correct interpretation of the law as at present existing, the punishment of offenders against the Federal statutes will be well-nigh impossible. Concerning the case of the Carter contractors he says:

> The defendants are indicted for frauds upon the government of the gravest nature, and of very large extent, committed in connection with a trusted officer of the Engineer Corps, proofs of which are spread over five or six years of governmental operations at Savannah and Cumberland Sound, and involve, also, to a large extent, technical and scientific facts, capable of proof only by expert witnesses and accountants, and by the production of a vast mass of documentary evidence. The witnesses to substantiate the case are scattered throughout the United States, and it was with exceeding difficulty they were marshalled for the hearing before the Grand Jury in Georgia and that their attendance was arranged for at the trial before the petit jury.
>
> To compel the government to make out a case of probable cause twice, once before a grand jury and afterward before a local magistrate in another jurisdiction, is imposing a more onerous condition for the punishment of crime than exists under any other form of government.

Congress has several times been on the point of interfering in the Carter case to expedite the conviction and punishment of the guilty. It now has an opportunity of rendering practical aid to the Government's law officers in this case, and at the same time curing a most serious defect in the Federal statutes for the punishment of criminal offenders. The Senate passed the Griggs bill on April 16, and it is to be hoped that the House will promptly do the same.

Judge Brown, who refused to issue the warrant for the removal of the Carter contractors to Savannah, is quoted as objecting to the Griggs bill on the ground that under it:

> citizens might be removed from their homes to distant parts of the country to stand trial on the mere finding of a distant grand jury, acting in secret and not making known any circumstances showing probable cause that an offense has been committed.

The sufficient answer to this appears to be that under the law an indictment must be found in the district where the offense is committed. There is no hardship in making a man answerable for his acts at the place where he commits them. There is serious danger to the public safety, however, if a counterfeiter, a mail robber, or a dishonest Government contractor can, by claiming residence in some part of the country remote from the scene of his crimes, add another skein to the maze of legal red tape that must be unwound to secure his conviction.

We hardly need to call attention, so important is the subject and so well-known the author, to the abstract in this issue of the report by Mr. J. R. Freeman, M. Am. Soc. C. E., on the water waste and water supply of New York city. The New York public, outside of engineering and insurance circles, has heretofore heard less of Mr. Freeman than is the case in Boston, Providence and other sections of New England. This report, however, should convince any unprejudiced layman that its author is a thorough master of his subject, while engineers generally will welcome it as the most important contribution that has appeared for a long time upon the subject of water waste, its prevention and the legitimate demands for water consumption in a large and growing city. The report shows conclusively that New York, though using less water per capita than some large American cities, is absolutely wasting much more water than it is really using, and that this waste might and should be stopped. The report also shows that the Ramapo scheme is, if possible, even worse than it has been painted, there being plenty of water within reach that can be delivered at as high an elevation (300 ft.) as that vaguely proposed in the Ramapo contract, and at far less cost, including sinking fund requirements sufficient to meet the whole cost of the new supply in 40 years.

AUXILIARY PIPE SYSTEMS FOR EXTINGUISHING FIRES.

The recent disastrous fire at Greenpoint, N. Y., and the fact that had it not been for the active work of the fireboats a large part of Long Island City might have been laid in ashes, calls general attention to two important matters: the inadequacy for fire extinguishing purposes of the pressure in the small pipe systems connected with the general water supply; and the great value of an auxiliary water pipe system for the extinction of fires. The Greenpoint fire broke out on the river bank, where an abundance of water was near at hand; yet the land fire engines had to depend on a system of 6-in. mains, with "dead ends" and a very poor circulation of water. As a result, there was little pressure on the fire streams, and the engines failed to get a sufficient quantity of water. The presence of the New York fire boats, taking water from the East River, alone prevented what might have been a most devastating fire. It was only due to the good judgment of Commissioner Scannell that these were available; for but half an hour before the Greenpoint fire broke out, a request for the fire boats came from the authorities of Bayonne, N. J., and was refused.

An auxiliary salt water fire service is now established in Boston; and a special pipe system taking water from the Lakes is in successful operation in Cleveland, Milwaukee, Detroit and Buffalo. There is no reason why such pipe systems should not be installed in New York, especially in the district where fire risks are greatest. The experience at Greenpoint emphasizes the wisdom of Mr. Scannell's recommendation that one be established in that locality.

Such special pipe systems can be either connected with the powerful pumps of the fire boats; or, where the conditions warrant it, they can be operated from special permanent pumping stations located on the river front. With ample mains and hydrants provided, the largest of the New York fire boats, the "New Yorker," can furnish a volume of water equal to that from 30 steam fire engines. It has a pumping capacity of 13,000 gallons per minute. The six New York and Brooklyn boats in service have a combined capacity of 40,000 gallons per minute; or the effective equivalent of 90 ordinary fire engines under high duty conditions.

It has been held in the past that salt water could not be used in extinguishing fires, because it would rust out the mains and damage goods. But salt water has been used for years in the pipe systems on board ships without serious damage to the pipes; and experience in Boston and elsewhere has proven that with ordinary precautions in coating and jointing, the pipes used for salt water will last for many years. As to the damage to goods, this objection has received no endorsement from the fire underwriters; and the fact that 32% of the water now thrown upon New York fires is salt water supplied by fire boats, is a sufficent answer.

For particular areas, adjacent to the North and East rivers, covered with warehouses which are filled with goods of enormous value, the special pipe system is peculiarly adapted. It is, moreover, very inexpensive when compared with the benefits to be derived. In an investigation recently made by an engineer of long experience, it was stated that a high pressure fire protection system covering the "Dry-Goods District" of New York, would cost only $110,000; and one covering the whole city south of Chambers St., and from river to river, would cost only $300,000. It was also shown that while the fire losses in Districts 2 and 3, of which the Dry-Goods District is a part, average about $3,000 per acre annually; the whole cost of installing an auxiliary fire service is estimated at only $1,100 per acre. The only valid objection advanced against the introduction of such a system is the inconvenience of an additional line of pipe in the street; but in some cases this could be overcome by removing old pipes that are no longer used for any purpose.

The recommendation of such an auxiliary service is entirely in the interest of greater safety against damages by fire, as secured by an unlimited supply of water under efficient pressure. It has practically nothing to do with the conservation of the general water supply of the city, for the total annual consumption of water in Manhattan and the Bronx, in extinguishing fires, only amounts to about 46,000,000 gallons, according to the reports of the Fire Department. This is less than a quarter of one day's general consumption for the territory in question. For fire extinction alone, however, the extra pipes and pumps would be of incalculable service; and as a large part of the stored wealth of Greater New York lies on or near the banks of its two great rivers, the conditions are peculiarly favorable for adopting such a comparatively inexpensive means of protection.

Onward Bates, M. Am. Soc. C. E., Engineer of Bridges and Buildings.

American Bridge Works, Chicago, Ill., Contractors.

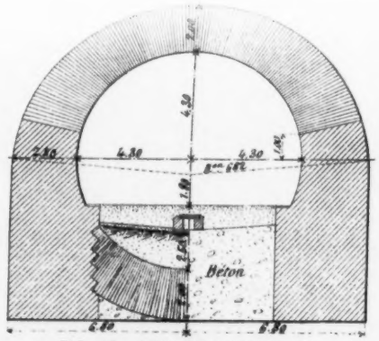


FIG. 10. NEW ARCH SECTION COMPLETE.

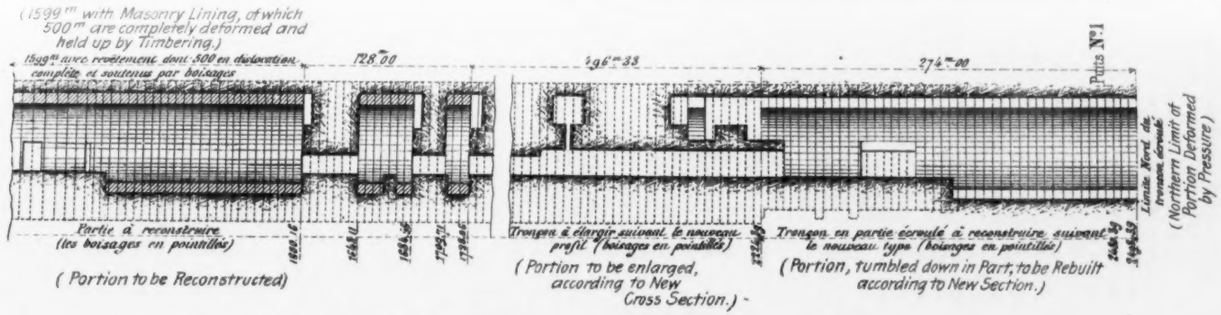

(1599m with Masonry Lining, of which 500m are completely deformed and held up by Timbering.)
1599m avec revêtement, dont 500m en déformation complète et soutenus par boisages
128.00
196m.38
274m.00
Puits N°1
Partie à reconstruire (les boisages en pointillés)
(Portion to be Reconstructed)
Tronçon à élargir suivant le nouveau profil (boisages en pointillés)
(Portion to be enlarged, according to New Cross Section.)
Tronçon en partie écroulé à reconstruire suivant le nouveau type (boisages en pointillés)
(Portion, tumbled down in Part, to be Rebuilt according to New Section.)
Limite Nord du tronçon écroulé
(Northern Limit of Portion Deformed by Pressure)

FIG. 1. LONGITUDINAL SECTION OF TUNNEL UNDER RECONSTRUCTION.

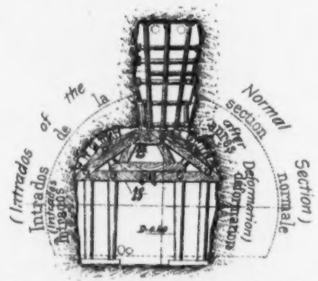


FIG. 2. CROSS SECTION SHOWING TOP ATTACK.

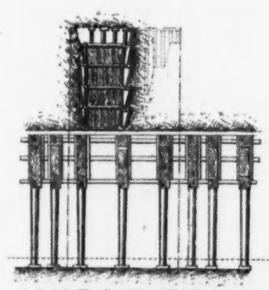


FIG. 3. LONGITUDINAL SECTION SHOWING TOP ATTACK.

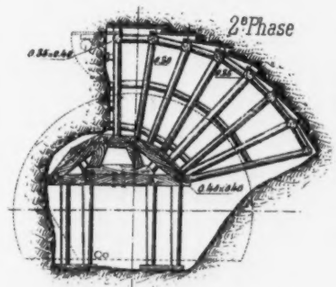


FIG. 4. ENLARGEMENT FOR NEW ARCH.

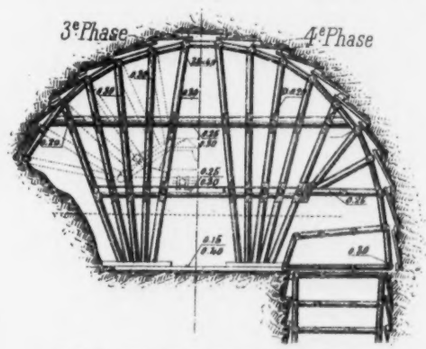


FIG. 5. ENLARGEMENT FOR NEW ARCH, CONTINUED.

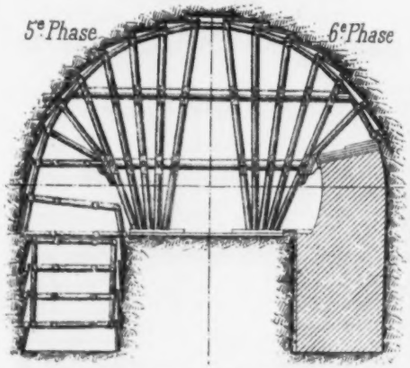


FIG. 6. BUILDING OF FOUNDATIONS AND SIDE WALLS.

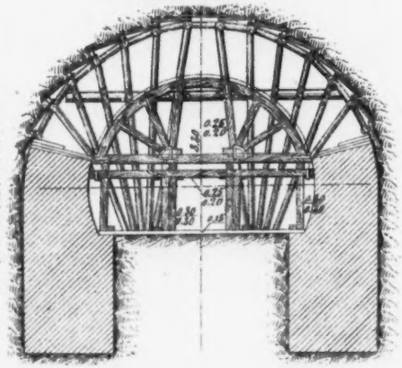


FIG. 7. ARCH CENTERS AND COMMENCEMENT OF ARCH.

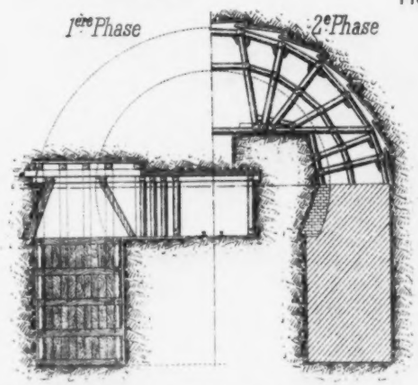


FIG. 8. SHOWING ENLARGEMENT OF CENTRAL GALLERY.

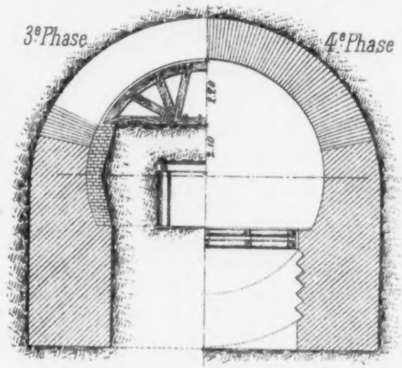


FIG. 9. BUILDING ARCH.

THE RECONSTRUCTION OF THE RONCO TUNNEL, NEAR GENOA, ITALY.

CHAS. HART, LITH., 26 VESEY ST., N. Y.

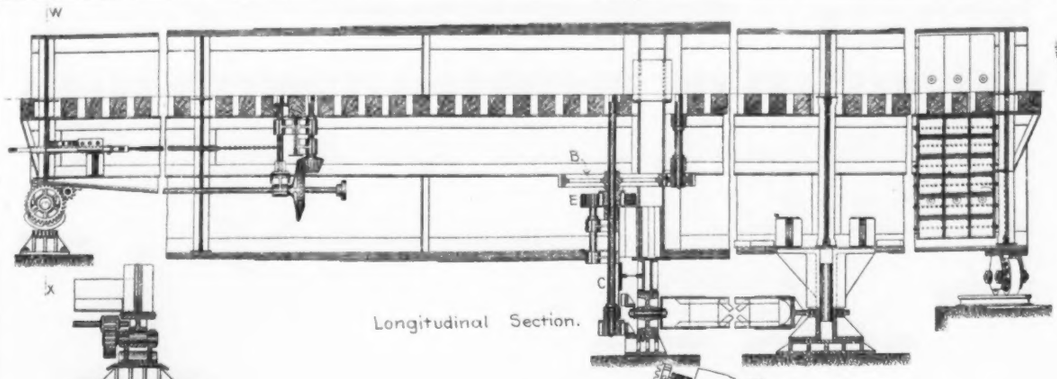


FIG. 3. SECTIONAL ELEVATION AND PLAN LONGITUDINALLY OF BRIDGE.

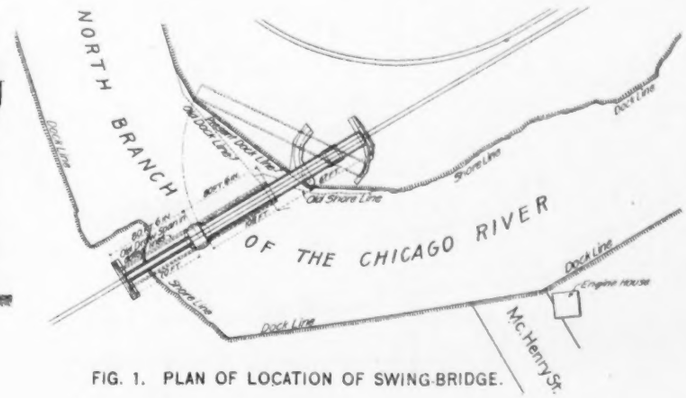


FIG. 1. PLAN OF LOCATION OF SWING-BRIDGE.

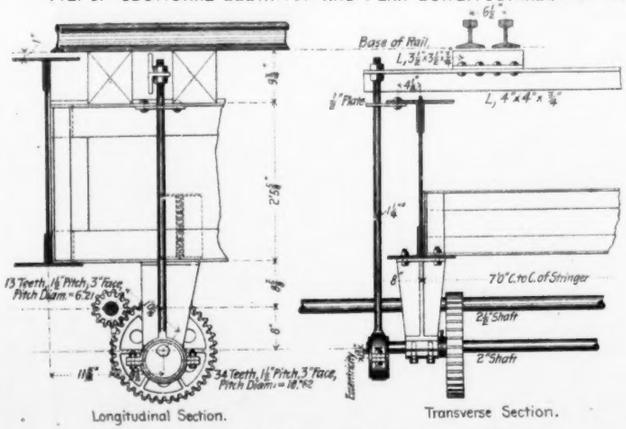


FIG. 5. DETAILS OF RAIL LIFTING MECHANISM.

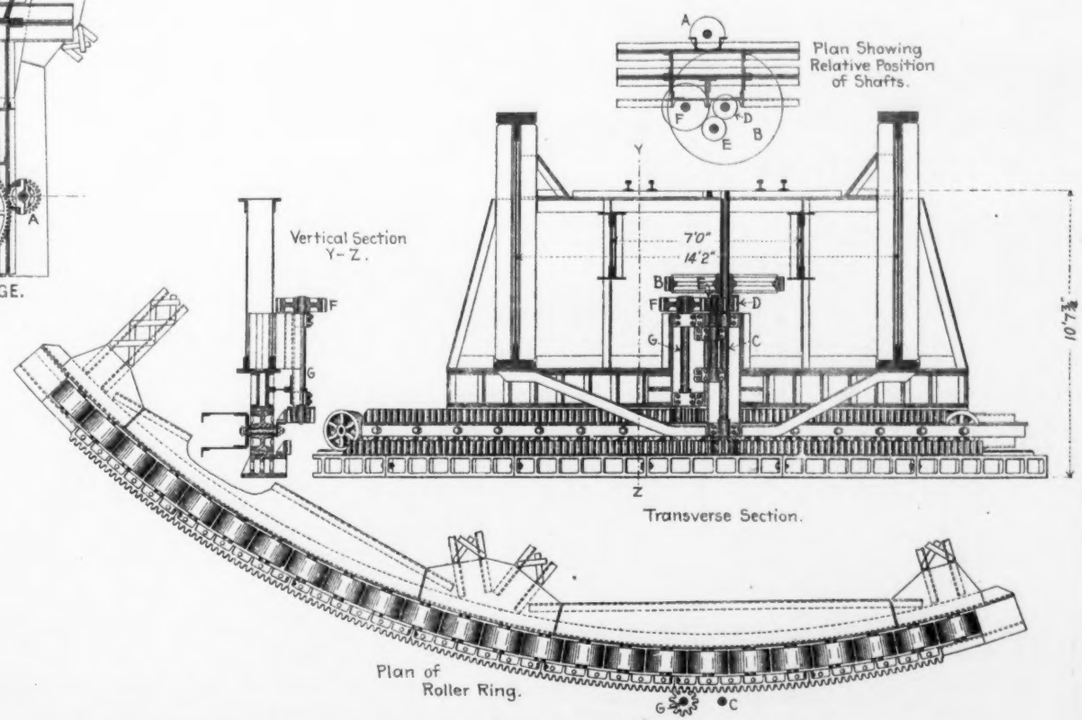


FIG. 4. SECTIONAL ELEVATIONS AND PLANS TRANSVERSELY OF BRIDGE.

OPERATING MACHINERY FOR 175-FT. COUNTER-BALANCED PLATE GIRDER SWING-BRIDGE,

CHICAGO, MILWAUKEE & ST. PAUL RY., CHICAGO, ILL.

Onward Bates, M. Am. Soc. C. E., Engineer of Bridges and Buildings. American Bridge Works, Chicago, Ill., Contractors.

LETTERS TO THE EDITOR.

Notes on the Driving and Lining of the Little Tom Tunnel; Norfolk & Western Ry.

Sir: I was very much interested in the article published in your issue of March 22, 1900, describing the relining of a tunnel on the Norfolk & Western Ry. Some salient facts concerning this tunnel itself may prove of interest to engineers, and it may be well to put on record the length of the life of tunnel timbering, as evinced by this particular case. The tunnel in question, during its construction, was known as Little Tom tunnel, being driven through the divide between the waters of Little Tom Creek and Bull Run, the former a tributary of Guest River, and the latter of Clinch River, and all in Wise county, Virginia. The tunnel is one of the five occurring in the line of the Clinch Valley Division, Norfolk & Western Ry., between St. Paul and Coeburn, Va. In this connection it may be stated that this portion of the track is one of the finest pieces of railway location in the United States.

The tunnel was constructed during the years 1888, 1889 and 1890. The west heading was started May 4, 1888, and the east heading Oct. 8, 1889; the headings met March 2, 1890. The west bench was started Nov. 9, 1888; the east bench April 7, 1890; they met on Oct. 29, 1890. The material through which the tunnel was driven is a gray sandstone, which forms the top and bottom of the numerous coal measures found in that section of country. The strata lies approximately level and vary from a few inches to several feet in thickness. Portions of this rock disintegrated upon exposure to the air, necessitating timbering at certain points. The length of the tunnel between timber portals is 1,925 ft., the elevation of the east portal at subgrade is 1,989.04 ft., and that of the west portal is 2,021.59 ft., all above sea-level. The grade through the tunnel is 1,691 ft. per 100 ft. ascending westwards, or at the rate of 89.28 ft. per mile. The tunnel is located on a tangent throughout.

Fig. 1 is a profile of the tunnel, showing monthly progress, location of original timbering, and other information. The style of timbering employed is shown by Fig. 2. The width at the bottom between posts is 13 ft., at the springing line it is 15 ft.; the height between subgrade and the bottom of the center arch timber is 20 ft. The posts are 8 × 12 ins. in section, and spaced 3.5 ft. apart c. to c. There are three arch timbers, each 10 × 12 ins. The wall plate is 12 × 12 ins.; the bottom plate 6 × 12 ins.; keyed up by wedges resting upon 3-in. blocks. The lagging is 3 ins. thick, and was generally used over the arch only. All the timbering was of first-class white oak.

The amount of timbering per lineal foot approximated 250 ft. B. M. A portion of the timbering was done by force account and the remainder by contract. The contract price for the timbering was $60 per M. ft. B. M., making the timbering cost about $15 per lineal foot. The area of the rock section is 263.66 sq. ft., or 9.765 cu. yds. per lineal foot. That of the timber section, 314.16 sq. ft., or 11.635 cu. yds. per lineal foot. The contract price for the excavation was $3.50 per cu. yd. The cost of the respective sections per lineal foot being thus $34.17 and $40.72. Some allowance for breakage outside of the regular sections was made, and for this the contractor received $1.50 per cu. yd. Stone packing over the timber arch was paid for at the same rate. The cost of the tunnel was about $115,500, or $60 per lineal foot, divided about as follows:

Excavation, per lineal foot	$43.00
Packing, " " "	1.00
Timbering, " " "	16.00
Total	$60.00

The tunnel was partly driven by hand and partly by machine drills. The daily progress in the heading ranged from 2 to 6 ft., while that of the bench was from 2 to 4 ft. daily. Work in the tunnel was not prosecuted continuously; there were several stoppages, as an inspection of the progress profile will show.

After the track was laid through the tunnel, the roof of that portion of the tunnel not timbered gave evidence of failure, large slabs, 6 ins. or more in thickness, falling at frequent intervals. It was decided to prevent further falls by timbering this part also, and the design shown in Fig. 3 was adopted, it being a modification of the standard section minus the posts. This work was done by the railroad company's own forces by day labor.

Respectfully,
Emile Low, M. Am. Soc. C. E.

Buffalo, N. Y., March 26, 1900.

Random Notes from Cincinnati to Portland, Oregon.

Sir: "Westward the tide of empire takes its way" was never exemplified in a more remarkable manner than in the great rush westward as a result of the Cape Nome gold discoveries. All trains for the West are well filled with passengers for the Pacific Coast, even by the somewhat roundabout routes.

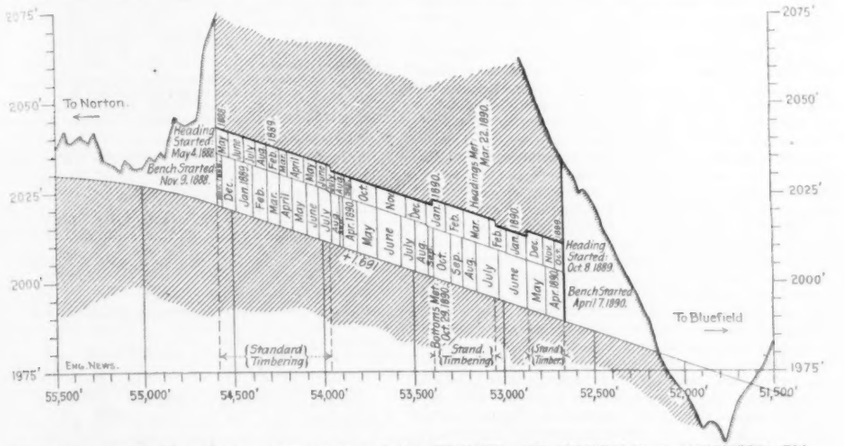


FIG. 1.—PROGRESS PROFILE OF LITTLE TOM TUNNEL ON NORFOLK & WESTERN RY., CLINCH VALLEY DIVISION.

The Monon route from Cincinnati to Chicago is over the C., H. & D. R. R. to Indianapolis, where the C., I. & L., or Monon proper, is reached. This road has been greatly improved since its reorganization, and future betterments are contemplated by the ballasting of 30 miles of track with gravel, the laying of 26 miles of 75-lb. steel rail between Fair Oaks and Monon, new steel bridges over the Wabash at Lafayette and Delphi, and the replacing of about 3,000 ft. of trestle with stone culverts and fills of stone arches.

This is but a fair example of the great improvements which are in progress on many of the Western railways. As a result, the running time of trains has been greatly reduced; the "Q" flyer to Denver, for example, has recently shortened its running time 2½ hours, leaving Chicago at 4 p. m., and reaching Denver the next day at 6:20 p. m.

The two features at Chicago of most interest to the visiting engineer are the dirty streets, known of old, and the clear water in the Chicago River, which was not known of old. The demand of shipowners for the lowering of the street railway tunnels under the river means the working out of some difficult engineering problems at great expense, and a storm of protest has arisen, which will likely only end after expensive litigation has forced the improvement.

The extended strikes among the Chicago trades have practically stopped building operations, and the new post office has only the skeleton steelwork partially completed.

At Omaha the new stations* of the Burlington and the Union Pacific are very convenient and elegant in design and appointments, but it is unfortunate that they were not consolidated since they are so very close together.

The city council of Denver has just granted permission to the Tramway Company to change its cable and horse car lines to electric traction. Through the business portions of the city, iron pipe poles set in Atlas cement con-

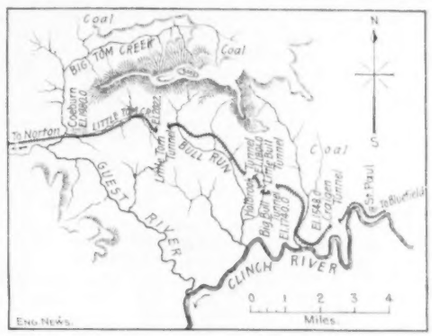


Fig. 4.—Map of Part of Clinch Valley Division, Norfolk & Western R. R., Between St. Paul and Coeburn, Va.

crete are being used; while farther out, wood poles are employed. The present tracks with cable slots will not be torn up, but the rails will be bonded and used as they are for the present.

The work on the new sewers is progressing quite rapidly, trenching machines being in operation on several different sections. The new Colfax Ave. viaduct, which will be a very long structure, will be constructed at an early date, and it is probable that the new Nineteenth St. viaduct, which is to be paid for by the railways, will also be built soon, as the railway companies interested have all been reorganized and action has been taken to compel them to go ahead with the work.

The purchase of a Seventeenth St. corner by Stratton, the famous discoverer of the Independence mine at Cripple Creek, on which to erect a monumental business block, promises to give Denver a building to compare favorably with those in the great cities of the East.

The Colorado & Southern Ry. has awarded the contract for new shops at Denver, to cost about $80,000. They will consist of a machine shop, car shop and round house. The company has under way other important improvements, including a 100-mile extension from the Leadville line through Platte Canon to Cripple Creek and to a connection with the Colorado Midland, which is quite sure to be consolidated with it, thus giving Denver a short line to the West in place of the detour at present necessary through either Colorado Springs or Pueblo.

There is the usual crop of rumors of new Pacific Coast lines. The one which seems most likely to materialize in actual construction is an extension of the Burlington. This company has now under construction a branch from Alliance, Neb., to Hartville, Wyo., a distance of 141 miles. The extension from Alliance to Brush, Colo., 110 miles, which is also under way, will give Denver a direct line to the Black Hills.

The Central City mining district, where Senator Teller has large investments in gold mines, is perhaps second in importance to Cripple Creek in gold production, and a trip there over the Clear Creek Canon line of the Colorado Southern was of considerable interest. From Black Hawk to Central City there is a very heavy climb in a few miles, and switchbacks, back and forth along the

*Eng. News, May 4, 1899, June 1, 1899.

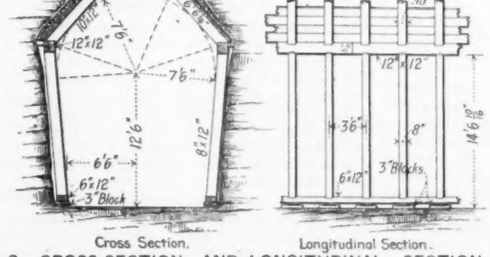


FIG. 2.—CROSS-SECTION AND LONGITUDINAL SECTION OF LITTLE TOM TUNNEL, SHOWING TIMBERING.

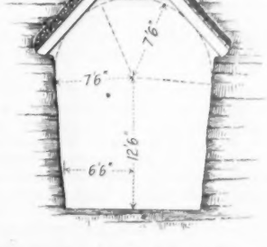


Fig. 3.—Cross-Section Showing Method of Timbering Used After Completion of Tunnel.

mountain side, are employed and seem much more daring than the famous Georgetown Loop on the same road.

The mines are in nearly all cases shafts, which in one visited was 225 ft. deep and at a slight angle with the vertical to follow the vein, which is a galena and pyrites-bearing lava rock. Most of the mines use steam hoists, but in some of the smaller mines horse-power is employed. The descent was made by wadding oneself into a mine bucket, which was some inches too short for comfort, and then being lowered down, the bucket bobbing and wobbling around in a very disturbing manner. At different levels, galleries are run off at right angles to the several veins of ore, and from these cross tunnels are driven to follow the veins, which are in many cases only from 15 to 20 ins. in thickness, so that a large amount of useless rock must be blasted out and removed to make room for the working. As the ore is taken out of the mine, it is roughly graded and then sent to the stamp mills and concentrators; at present much of it goes to improved mills at Idaho Springs, but two new mills are being built at Black Hawk, one with a capacity of 300 tons of ore per day, so that in the near future there will be capacity enough to take care of the whole product of the mines in the best manner.

Coincident with the great impetus which has been given to gold mining and the large increase in production of the yellow metal, has come about a great change in public sentiment in this section over the 16 to 1 question, and some even discuss seriously what will be done when it becomes necessary to demonetize gold!

The Newhouse tunnel from Idaho Springs is projected to run through the mountains to Central City, a distance of six miles, as a purely mining proposition, to intercept the various veins of ore.

The Colorado Midland Ry. from Denver to Grand Junction is one of the remarkable mountain roads of the world, both as an engineering work and for its scenery. For some time after the separation of the road from the Santa Fe system, the Busk Tunnel was not used, owing to a disagreement between the railway company and the owners of the tunnel, and the old line around was reopened. The railway company has recently purchased the tunnel, and by its use saves nine miles of snow fighting every winter. During the winter of '98-'99 they had 77 days of snow fighting, and once when the rotary snow plow broke down, parts for its repair had to be taken across the mountains over the snow on a toboggan, before a snow-bound train could be released. This resulted in the purchase of a new rotary plow of the best and strongest possible design throughout and weighing 130 tons. It has a 67-in. Belpaire boiler for 190 lbs. pressure, engine cylinders 18 × 26 ins., while the cutter wheel is made with 12 conical tubes, each one of which carries a knife 4 ft. 6 ins. long. The snow passes into the tubes and is thrown out through the hood by centrifugal force.

So excited has the West become over new gold finds that when a prospector had an assay made of a find from Two-Bit Gulch, near Leadville, which showed 40 oz. of gold to the ton there was a general rush of people to stake out claims. Even after finding out that the specimen was concentrate from an old dump, the rush continued until there were claims staked out all over the gulch.

Near Cardiff is found a good coking coal, and along the railway were seen numerous coke ovens in operation.

The roadbed of the Midland has been much improved, and at New Castle a new steel bridge has been built and a new station completed. From here to Grand Junction a joint track is maintained in conjunction with the Rio Grande Ry.

A new beet sugar factory at Grand Junction is completed and will have a capacity to use beets from 3,500 acres of land. There is another sugar factory at Lehi, Utah, where the land is said to produce 13½ tons of beets per acre, with a net value of about $50 to the acre. Quite a remarkable method of transporting beets is the pipe line from Springville to Lehi, a distance of 25 miles, the beets being crushed first at Springville.

The little town of Fruita, on the Rio Grande Western, surprises one by having an astronomical observatory perched above a private residence near the station, the property of some scientific exile from the East.

The Edgemoor Bridge Co. are replacing the iron bridge over the Green River, near Green River station, by a new steel camel-back structure of modern strength and design.

Just before reaching Green River, a loud report was heard. It proved to be the blowing out of a pipe on the steam dome, as the result of the alkali in the water eating out the thread on the pipe and in the hole. Owing to a lack of tools and material to repair the break, the train was side-tracked to await another engine. With the assistance of the writer, however, the hole was plugged by a brass plug which was clamped in place by a wood lever, the short end of which was wedged in between the flanges of two other pipes on the dome back of the plug, while the long end ahead was pulled down by using a twister in some bell cord tied to the lever and to the hand rail on each side of the boiler. The plug was so securely held that steam was raised to 160 lbs. pressure and the train was started and safely completed its journey to the end of the division.

The Tarbet mining shaft at Bingham, Utah, is to be sunk at once to a depth of 400 ft. to connect with a tunnel, from which the working may be continued in both directions. The work will be prosecuted with an electrically driven hoist and pump.

Plans are nearly completed for the erection at Salt Lake City of a new Union station for the use of the Rio Grande Western and the Oregon Short Line. Electric railway enterprises are numerous and the proposed line to Ogden will doubtless be built as soon as the necessary franchises and rights of way have been secured.

The only move which seems to promise a Salt Lake-Los Angeles line with any certainty is the purchase of the Carson and Colorado road by the Southern Pacific Co. It is proposed to build a connection to it from Wadsworth, Nevada, and President Huntington assures California people that he will build a connection from the Southern terminus at Keeler to Mojave, Cal., and standard gage the whole line.

The Southern Pacific has in operation across San Francisco Bay the new double-ender screw ferry boat "Berkeley,"* which in many respects surpasses even the fine ferry boats of the Pennsylvania R. R. on the North River.

The new Union station† at San Francisco, while answering its purpose in a splendid manner, is a disappointment as a work of architecture, the long, low building not having mass enough to justify the "Madison Square Garden" tower which rises from its center. The terminals of the Market St. cable lines at the station are well laid out and the lines are as effective as ever in handling the traffic.

The most notable new buildings in San Francisco are the Spreckles skyscraper of 16 stories, with its striking dome topping out the mass, and the new post office, which is only partly completed. The walls of the latter are being built by stiff-leg derricks set on top of the steel frame and served by electric hoists.

The business of the city has been much benefited by the sailing of the army transports from there to the Philippines, the number of sailings amounting to about 160 since the war began, while the sailings of naval vessels has also been very large.

The Mare Island Navy Yard is being practically reconstructed, several new steel frame buildings having just been completed, one of which is a new machine shop in which the machines are all of the latest design and with separate electric motors to drive them.

Work has been commenced on the great new masonry dry-dock by the Atlantic, Gulf & Pacific Co., of New York city. This will be put in at an angle with the old granite dock and a new pumping plant will be built between them. Work is also under way on the new sea wall, and the San Francisco Bridge Co. are dredging the new channel, having a fleet of three large hydraulic dredges.

Repair work is under way on several vessels of the navy, two of which are old wooden vessels which should be relegated to the bone yard, and new steel ships put in their places.

The Risdon Iron Works of San Francisco have acquired the Pacific Rolling Mills and will expend a large amount in modernizing them and in constructing large shipyards, thus giving the coast another plant big enough to handle large steel vessels.

When compared with the "Owl," the fast express on the Southern Pacific to Los Angeles, the trains to Portland seem outrageously slow, but after one has ridden over the steep mountain grades of the Shasta Route, the slowness is in some measure accounted for. The train of twelve cars was fully loaded with passengers and baggage bound Cape Nomeward, and three engines were put on for the climb over the Siskiyou Mountains, where from Hornbrook to the summit the rise is nearly 2,000 ft. in less than twenty miles, the maximum grade being about 3½%. The speed in many places was not much faster than a walk. As wood is used for fuel on the locomotives, they presented an unusual appearance in having wood piled on the tender to twice its height or above the top of the train.

The Shasta Mountains, which are crossed before the Siskiyous, do not present any great difficulties, although two engines were necessary. The view of Mt. Shasta is fine, and at Shasta Springs time is given for passengers to imbibe Shasta mineral water.

After passing Siskiyou station at the summit of the mountains, there is a high timber viaduct, with towers eight stories high and Howe truss spans from tower to tower; this is to be replaced with a steel viaduct by the Phoenix Bridge Co., who have much of the steel work at the site; the foundations for it being under way. Some of the bridge spans along the line have been replaced by new steel structures, and with new ties and new gravel ballast it is likely that fast trains will soon be put on.

The timber all along the line of the road is very small and scattered, the big trees having been mostly used for timber, but there is much good timber farther back, as is evidenced by the logs in the streams.

After leaving the mountains the Rogue River Valley is entered, where are beautiful orchards and farms. Although the snow was in sight and almost in reach, the fruit trees were in full bloom, as they were all through Southern Oregon.

C. E. F.

Portland, March 31, 1900.

*Eng. News, Dec. 29, 1898.
†Eng. News, July 29, 1897.

Formulas for Computing Quantities of Brickwork in Egg-Shaped Sewers.

Sir: Recently I had occasion to compute the brickwork in certain egg-shaped sewers, and not knowing of any formulas from which immediate results might be obtained, I proceeded to develop some for my own use, as follows:

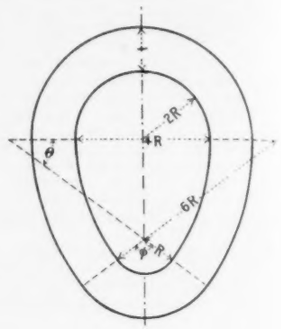


Fig. 1.

In Fig. 1, let

R = radius of invert, in ins.; and
t = thickness of sewer wall in ins.
θ = angle opposite side arc.
φ = angle opposite invert.

Then by construction

$2R$ = radius of upper arc, and
$6R$ = radius of side arcs.

Area of cross-section of sewer wall

$$= \left\{ \frac{(2R+t)^2 - (2R)^2}{2} + \left\{ (6R+t)^2 - (6R)^2 \right\} \frac{2\theta}{360} + \left\{ (R+t)^2 - R^2 \right\} \frac{\varphi}{360} \right\} \pi;$$

$$= \pi \left\{ \frac{4R^2 + 4Rt + t^2 - 4R^2}{2} + \left\{ 36R^2 + 12Rt + t^2 - 36R^2 \right\} \frac{2\theta}{360} + \left\{ R^2 + 2Rt + t^2 - R^2 \right\} \frac{\varphi}{360} \right\};$$

$$= \left\{ \frac{4Rt + t^2}{2} + (12Rt + t^2) \frac{2\theta}{360} + (2Rt + t^2) \frac{\varphi}{360} \right\} \pi. \qquad (1)$$

Now angles θ and φ are fixed, and by computation are found to be

$$\theta = 36^\circ\ 52'\ 11\tfrac{1}{2}'' = 36.8699^\circ, \quad \therefore \frac{2\theta}{360} = .2048;$$

$$\varphi = 106^\circ\ 15'\ 37'' = 106.2603^\circ, \quad \therefore \frac{\varphi}{360} = .2950.$$

Substituting these values in (1) and reducing, we get

$$\left\{ \frac{1.9996\ t^2 + 10.0952\ R\ t}{2} \right\} \pi = [.9998\ t^2 + 5.0476\ R\ t]\ \pi$$
$$= (3.141\ t^2 + 15.858\ R\ t) \text{ sq. ins.}$$

If we divide by 144, we secure $.0218\ t^2 + .11\ R\ t$, which gives very closely the number of cubic feet in a running foot of sewer of the type shown.

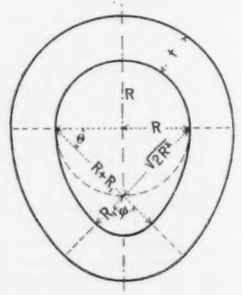


Fig. 2.

In Fig. 2 let

R = radius of upper arch; then
$2R$ = radius of side arch, and
$R_1 = 2R - \sqrt{2}R^2 =$ radius of invert.
Let θ = angle opposite side arches = 45°.
φ = angle opposite invert = 90°.

$$\text{Area} = \pi \left\{ \frac{(R+t)^2 - R^2}{2} + \left\{ (2R+t)^2 - (2R)^2 \right\} \frac{2\theta}{360} + \left\{ (2R - R\sqrt{2}+t)^2 - (2R - R\sqrt{2})^2 \right\} \frac{\varphi}{360} \right\};$$

$$= \pi \left\{ \frac{R^2 + 2Rt + t^2 - R^2}{2} \right.$$

$$+ (4R^2 + 4Rt + t^2 - 4R^2)\frac{90}{360}$$

$$+ (6R^2 - 4R^2\sqrt{2} + 4Rt - 2Rt\sqrt{2} + t^2 - 6R^2 - 4R^2\sqrt{2})\tfrac{1}{4}\Big\};$$

$$\pi\left\{\frac{2Rt+t^2}{2} + \frac{4Rt+t^2}{4} + \frac{4Rt-2Rt\sqrt{2}+t^2}{4}\right\};$$

$$\pi\left\{\frac{4Rt+2t^2+4Rt+t^2+4Rt-2Rt\sqrt{2}+t^2}{4}\right\}$$

$$\pi\left\{\frac{6Rt+2t^2-Rt\sqrt{2}}{2}\right\};$$

$$1.57\,[6Rt+2t^2-Rt\sqrt{2}];$$

$$1.57\,[4.5834\,Rt+2t^2];$$

$$7.1959\,Rt+3.14\,t^2;$$

which for all practical purposes may be written

$$7.2\,Rt+3.14\,t^2, \text{ in sq. ins.}$$

If we divide this by 144 we get the number of cubic feet per running foot, or $.05\,Rt + .0218\,t^2$.

Very truly yours, Philip P. Farley, C.E.

215 Montague St., Brooklyn, N. Y., Mar. 19, 1900.

(In our issue of May 14, 1896, we published an illustrated article on "Tables and Diagrams for Facilitating the Computations of Estimates for Sewerage Work," by Mr. S. M. Swaab, of Philadelphia. There were no formulas in the article, but the tables and diagrams would enable anyone to make estimates with rapidity for a wide range of sizes and other conditions. The article was republished in pamphlet form. Some quite detailed tables to the same end are given in a handy little English volume entitled "The Sewerage Engineer's Note-Book," by Mr. Albert Wollheim, Assoc. M. Inst. C. E. This book also gives an easy method of computing the number of brick per unit length of sewer by determining the proper coefficient of the radius for any given cross-section of sewer and size of brick, so that only the value of the radius need be substituted in any case. Tables of brickwork quantities may be found in the various engineers' pocket-books.—Ed.)

Is the Trouble at the Austin Dam an Argument Against Municipal Ownership?—Continued.

Sir: I venture to take exception to a few of your remarks in your issue of March 29 on my letter in regard to municipal ownership.

You make a statement that the engineers employed by municipalities rank higher than is the case with most of the other municipal officials. Without disputing this, I wish to point out that the comparison is not between municipal engineers and other municipal officials, but between municipal engineers whose salaries are low and whose appointments are often controlled by politics; and on the other hand, the engineers of private companies which pay salaries in proportion to the ability demanded. Of course, as you say, the mere fact of employment by a private company instead of by a municipality is no absolute assurance against bad judgment or dishonesty, but the best engineering ability will command the best salaries, and until municipal engineers are entirely out of politics and are paid as high salaries as the private companies pay for the highest engineering ability, it can hardly be claimed that municipal engineers will average as high in ability as the engineers of the private companies, which demand a high grade of ability and are willing to pay for it.

Your second statement to which I must take exception, is that consumers and taxpayers must foot the bills in the long run under either private or public ownership. If you claim, as this statement would imply, that consumers and taxpayers necessarily suffer all the ill effects of bad management under private ownership, you would necessarily admit that consumers and taxpayers benefit from the high dividends sometimes paid under good private management. Your illustrations show clearly that this is not the case. No one has ever proposed that the tax rate of New York should be raised in order to pay the unfortunate stockholders of the Third Avenue Railroad Co., or that the rate of fare on that road should be raised on account of its mismanagement. Likewise, it is the stockholders of the unfortunate Bay State Gas Co. (the one incorporated in Delaware) that have suffered, while the tax rate in Boston remains the same and the price of gas is only $1 per thousand for gas of 25 c. p., which is, I venture to say, as low a rate to the consumers as obtains in any city in this country, considering the distance from the coal mines.

On the other hand, as your reply very fairly states, the city of Austin is legally bound to assess its taxpayers in order to pay for its electric light and water plants. If this dam and plant had been built by private capital instead of by municipal ownership, the taxpayers of Austin would have been just that much better off, and the private owners who have supplied the money and ran the risk, would have stood the loss instead of the taxpayers.

Of course this question cannot be settled by a few cases; but what I wish to point out chiefly is that it is not fair to take the cases in which municipal ownership has been a success and to compare them with the failures of private ownership. The failures of municipal ownership must also be considered, and it must be remembered that the failures of municipal ownership must be paid by the municipality, but the failures of private ownership are paid by the private owners. If you ask me to find instructive object lessons nearer home, why do not you ask me to compare the West End St. R. R., a private corporation giving one of the best street car services in the world to the citizens of Boston, with the Municipal Ice Department of the city of Boston, the Electrical Construction Division of the city of Boston, or the Repair Department of the city of Boston, three municipal enterprises in Boston, that have just been discontinued because municipal ownership was costing anywhere from twice to fifteen or twenty times as much as the same service could be obtained for from private ownership?

Possibly we may find that we agree if we distinguish between municipal ownership of the franchise and municipal management of the business. The right or franchise to run street cars on the streets, or gas pipes, water pipes, electric wires, etc., under the streets, is, in a large city, of immense value. For a city to give away this right to a private corporation without compensation is unwise. It should, on the other hand, retain the ownership of the franchise and use its right of ownership either to reduce the burden on its taxpayers by exacting a franchise tax from the public service corporations; or it may use its right to secure reduction of the price of service to the customers of these corporations. The cities that have given away these franchises to private companies without compensation have suffered a heavy loss, while the cities that have retained the ownership of these franchises are in a much better position.

I submit, however, that for cities to own the actual plant of the public service corporations, or to manage the same, has been shown to be a mistake. There are of course exceptions where cities have built their plants and run them at a profit, but the general average of experience, taking the good cases with the bad, has been that municipalities get the best results when they retain the ownership of the franchise only, but leave the building of the plant and its management to private ownership.

Very truly yours, R. S. Hale.

31 Milk St., Boston, Mass., March 31, 1900.

P. S.—Since writing the above the failure of the dam by reason of a flood has been reported. I understand that the loss is complete, nevertheless the city of Austin must pay the bonds and suffer the whole loss. If the plant had been built by private enterprise the city would have been saved this loss, whatever the ability of the engineers. It will take a great many successful municipal plants to bring the average cost of the service anywhere near as small as the net cost to the taxpayers of private ownership, whenever a fair average is taken. Truly yours,

R. S. Hale.

(Our assertion that engineers as a class rank higher than other municipal officers was intended as a matter of justice to the profession, rather than as affecting the points at issue. We have never maintained that engineers employed by cities are, as a rule, properly paid, or even as well paid, on the average, as those in the service of private companies. But we are not prepared to admit that the average ability of the municipal engineers of the country, or those engineers whose time is devoted largely to municipal work, is not as high as that of the engineers employed by private corporations. Certainly the Austin dam, which started this discussion, does not prove that municipalities employ poorer engineers than do private companies.

As to whether consumers and taxpayers actually suffer when municipal franchise corporations are mismanaged, that is not theory, but experience. We do not say that they always and at all times bear the entire burden, but the great bulk of it falls on them. Street railways, gas-works, waterworks etc., must be kept in operation, and the whole cost of keeping them running must be paid by the public in the long run, including all expenditures due to mismanagement. In addition the "high dividends sometimes paid under good private management," to which our correspondent refers, also come out of the pockets of the public, and the unfortunate fact is that under private management of these monopolies there appears to be no limit to the paper capitalization on which these dividends are based.

As to the various city departments of Boston abolished by the new administration, we have not seen any definite and convincing ex parte statements. We think it very probable that their abolition was wise, as it is by no means established that the day labor plan is more advantageous than the contract system of conducting public works.

We heartily agree with Mr. Hale in his statement that the ownership of all municipal franchises should be retained by cities and towns and their rental value applied either to the reduction of service rates or general taxation, but we cannot assent to the propositions in his closing paragraph: That municipal ownership of the actual plants "has been shown to be a mistake," nor that "the general average of experience, taking the good cases with the bad, has been that municipalities get the best results when they retain the ownership of the franchise only, but leave the building of the plant and its management to private ownership."

Since the above was put in type the dam has failed, as set forth at length in our last and in this issue. On reviewing the history of the structure in our last issue, and on reading Mr. Frizell's letter of resignation (dated June, 1892), included in the communication from him embodied in our account of the failure, this week, it appears that there was a large amount of meddling with some of the engineers on the part of one or more of the city officials; more than we were aware of when we commented on Mr. Hale's first letter, or when we wrote the comments, just above. Whether or not this meddling contributed in any way to the earlier troubles with the headgates and power house, or to the recent failure, we leave for the present to our readers. It certainly strengthens Mr. Hale's argument against municipal ownership, but it does not at all shake our faith in the general soundness of our position. Very likely just such interference is more common under public than under private ownership; certainly it is more likely to be noised abroad; but unfortunately for the profession, the engineer's bed is not one of roses under either municipal or private engagements, and even when it appears to be, thorns are likely to be felt sooner than is expected.—Ed.)

Notes and Queries.

The address of Mr. W. H. Sadler, whose letter on Transition Curves appeared in our issue of April 12, is Waymart, Pa., instead of Newport, Pa., as printed.

G. asks concerning the publications of the International Congress on Navigation, to be held in Paris this summer. All papers will be printed in English, French and German. To obtain them it is necessary to become a Member of the Congress. But this can be done by sending name and address, and enclosing a bill of exchange, or post-office order, for 25 francs, to Monsieur G. Pavie, Secretaire General de la Commission d'organization, Chambre de Commerce de Paris, Place de la Bourse, No. 2, Paris, France. In asking for the publications the applicant must distinctly state in what language he desires them, as only one set will be sent.—Ed.

THE STRIKE AT CROTON DAM has at last called out the military; and two troops of cavalry from New York and Brooklyn and two companies of infantry from Yonkers and Mt. Vernon are at the seat of trouble. The strikers, who are all Italians, are already cowed, and protest that they meant no harm. They are armed, however, and little faith is placed in their declarations. The trouble arises from a demand for $1.50 a day of ten hours instead of $1.25, for common labor. The greater part of the men are skilled and better paid, and these are generally content, but are forced out by the others. The strike leader represents that $1.25 per day will not support the men; they pay from $14 to $18 a month for board and lodging, and lose sometimes all but ten days per month by inclement weather. The contractors say that $1.25 is the prevailing rate at the Jerome Park reservoir work, and an advance to common labor would mean a proportionate advance in all other classes of labor. Hence they will make no concessions.

THE "PENNSYLVANIA" CLASS OF BATTLESHIP, according to the nearly completed designs of the Naval Board of Construction, will be formidable ships; and the "Georgia" and "New Jersey" will be like the "Pennsylvania." Each will displace 15,000 tons and will be 400 ft. long and 75 ft. beam. The speed is to be 20 knots. The main water line belt will be of Krupp armor 8 ft. wide, extending from stem to stern, and 9 ins. thick, tapering to 5 ins. at the ends. Above this belt will be a 6-in. casemate, 100 ft. long, covering a broadside of 10 rapid-fire 6-in. guns. The four 12-in. guns, and the four 8-in. guns will

Nevertheless, Mr. Freeman judges, from observation here and elsewhere, that "the hopes of a cure for any large part of the waste are very remote," especially as all the water wasted and used in the two boroughs costs only $1 per capita, and the total consumption in Greater New York is less "than in most other large American cities."

Mr. Freeman's studies of waste form one of the most interesting parts of his report, and are a welcome addition to the available information on this important subject.

First of all, hook gage readings, at six-minute intervals, were made in the Central Park reservoirs at a time when all the water for Manhattan "was running through the new aqueduct, which was carefully held at a constant depth." The observations extended through ten days of mild December weather, no ice forming on the reservoir surfaces during the period, so there was no wasting on account of faucets running to prevent freezing, and very little for the sake of getting cool drinking water. The results (see also Fig. 2) and conclusions from these gagings are given by Mr. Freeman as follows:

Day after day the observations repeat with remarkable uniformity, reaching their maximum at 10 o'clock in the forenoon, dropping off a little from 11 to 1 p. m., rising again slightly at 2.20 p. m., falling off rapidly after 5 to 6 p. m., decreasing further after 10 p. m., until the minimum was reached about 3 or 4 o'clock in the morning, the draft until that time being kept up by the re-filling of the house tanks, etc.

Night after night the rate of consumption at 3 to 4 a. m. did not fall below 90 gallons per inhabitant per 24 hours, averaging about 94, while the highest point reached during working hours averaged at the rate of 137 gallons per inhabitant per day.

Thus the excess of consumption in the most active hour of the day was only at the rate of 43 gallons per inhabitant per 24 hours over that in the quietest hour of the night. The average of the whole 24 hours was only 21 gallons per inhabitant greater than the draft at 3 o'clock in the morning.

Late on Sunday night or early on Monday morning we would naturally expect the consumption to be at its minimum, for at that time domestic use is practically nothing, house tanks will have nearly all become refilled through the higher pressure of Sunday, the factory tanks will also have become re-filled, and almost the only legitimate use that can be imagined after Sunday midnight is that of the water required for the comparatively few newspaper offices, the filling of boilers for steam heat in some few buildings, a small quantity for electric light stations, and a little for hospitals or an infrequent household in which there is sickness, and for a house tank here and there which has not had time to become entirely replenished. After midnight, from 1 to 4 a. m., the record on Monday, December 11th, almost exactly reproduces that on Monday, December 4, in showing a draft at the rate of 95 gallons per inhabitant per day at this hour when legitimate use should be at its minimum. Granting that this measurement was correct (which we have no good reason to doubt) the simplest common sense shows that a large part of this large draft from the reservoirs at this quiet hour of the night must have been waste through leaky plumbing, leaky street mains and leaky and abandoned service pipes, and making the greatest reasonable allowance for uncertainty in measurement and for legitimate use at these hours, we are, I believe, forced to conclude that water was running to waste at night at the rate of 80 gallons per inhabitant per 24 hours.

A part of this waste must be regarded as incurable, for with the very best of pipe laying, it is found that the small undiscovered leaks in the thousands of joints, aggravated more or less by expansion and contraction under temperature changes and by settlement of the earth around the pipe causes leakage which in the aggregate is considerable.

In the City of Fall River, which has the distinction of water-works the most thriftily managed of any of equal size in the United States and where there is a meter on substantially every tap, domestic, manufacturing, public and commercial, and where close account is also kept of the water used for fires, flushing of streets, and the like, the discrepancy between the water pumped into the mains and that shown as taken out of the mains by the aggregate readings of all the service meters, and after making allowance for under-registry of meters, has not been brought below 6 gallons per inhabitant per day.

In Woonsocket, Rhode Island, another thoroughly metered manufacturing city with a population of about 28,000 supplied, the total water unaccounted for between the pumps and the service meters was in 1898—8.5 gallons per inhabitant per day; in 1899—7.8 gallons per inhabitant per day.

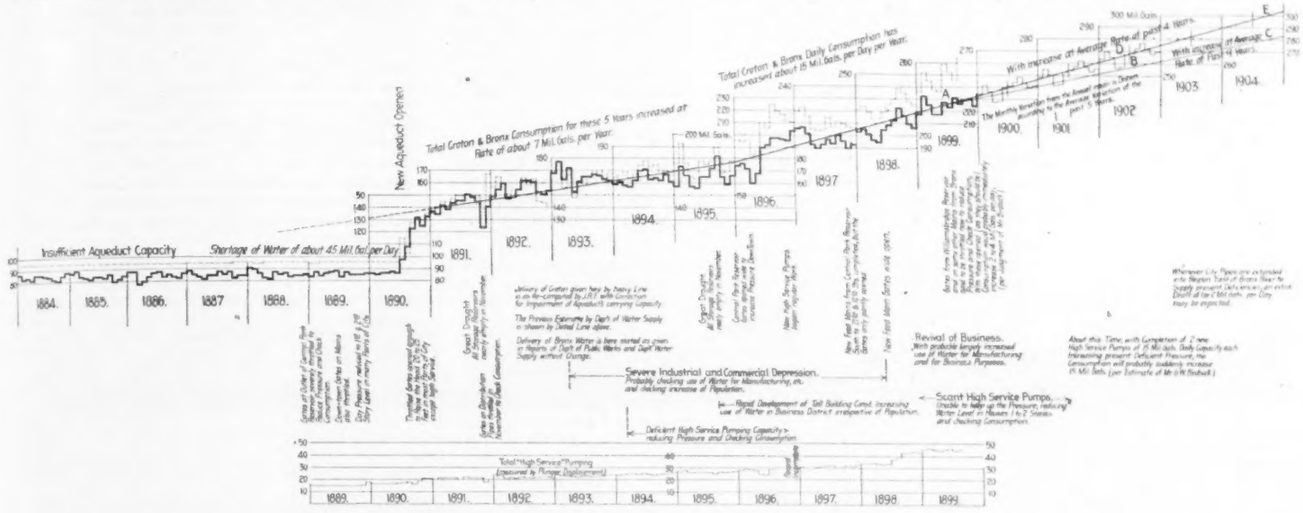
In two small districts of Boston, mentioned in the main report, very thorough work for about 5 months with the Deacon system of waste prevention, starting with a night consumption at the rate of 40 gallons per inhabitant per day, brought this down to a rate of 10 gallons per inhabitant per day.

Under equal quality of pipe laying and calking of joints, the waste through joints in the cast iron mains should be proportional to the aggregate length of these leaded joints, and the service pipe leakage between the mains and the cellar wall should be proportional to the number of service pipes.

Computation shows that the population along the New York distribution pipes is so much more concentrated than in any other American city, that the per capita waste from joint leakage in the street mains ought therefore to be very much less than found elsewhere. For example, it appears that the total number of pipe joints in Manhattan is not far from 350,000, and that the lineal feet of leaded pipe joints is not far from 1,250,000 to 1,500,000 ft., or, at most, there is only about 0.7 ft. of leaded pipe joint per capita in Manhattan and The Bronx, while in Fall River a similar computation shows 1.1 ft. of leaded joint per capita, and Providence—2.7 lin. ft. of joint per capita, or 4½ times as much as in New York. The number of service pipes per 1,000 inhabitants is only about one-half as great in New York as in certain fully metered cities, like Providence, Fall River, Worcester and Woonsocket, in which the consumption of water is less than one-half that in New York.

Judging from all the data, five gallons per capita is considered ample for incurable leakage, were it not for conditions peculiar to the crowded streets of New York, on which account ten gallons is assumed.

In 1898, there were 35,442 meters in use in New York, covering "every place where water is used to any considerable extent for other than domestic purposes." A careful study of records for several years in the offices of the Water Register and Bureau of Arrears, indicates that 24 of the 116 gallons per capita consumption is metered. Deducting curable and incurable waste, as shown by the reservoir gagings, of 80 gallons, leaves 12 gallons per inhabitant per day as the real domestic use of water. This compares well with the actual records from a number of metered cities, such


Total Croton & Bronx Consumption for these 5 years increased at Rate of about 7 Mil. Gals. per Year.
Total Croton & Bronx Daily Consumption has increased about 15 Mil. Gals. per Day per Year.
With increase at Average Rate of past 4 Years.
With increase at Average Rate of Past 5 Years.
New Aqueduct Opened
Insufficient Aqueduct Capacity
Shortage of Water of about 45 Mil. Gal. per Day
Severe Industrial and Commercial Depression.
Revival of Business.
Scant High Service Pumps.
Deficient High Service Pumping Capacity reducing Pressure and Checking Consumption.
Total High Service Pumping (Measured by Pumps' Displacement)
1884. 1885. 1886. 1887. 1888. 1889. 1890. 1891. 1892. 1893. 1894. 1895. 1896. 1897. 1898. 1899. 1900. 1901. 1902. 1903. 1904.

• FIG. 1.—TOTAL CONSUMPTION AND WASTE OF CROTON, BRONX AND BYRAM WATER IN NEW YORK (MANHATTAN AND THE BRONX), 1884-99.

Based on recomputation of flow by J. R. Freeman, M. Am. Soc. C. E., December, 1899, from data furnished by G. W. Birdsall, Chief Engineer Department Water Supply; by A. Fteley, M. Am. Soc. C. E., Chief Engineer Croton Aqueduct Commission, and from daily records of depths in aqueducts by keepers at Croton Dam, Sing Sing, Tarrytown and Central Park, with tables of aqueduct flow corrected in accordance with gagings by F. W. Watkins, M. Am. Soc. C. E., Assistant Engineer Aqueduct Commission, on New Aqueduct, Nov. 25-26, and Dec. 4-6, 1899, and on Old Aqueduct, Dec. 15-16, 1899; also probable consumption for next five years, if rate of increase is same as for the past.

There are strong reasons for expecting that consumption (and waste) will follow this upper line A-D-E unless (1) Water meters are attached to substantially all service pipes; (2) A Department of Water Statistics and Water Waste Prevention is established; (3) The systematic search for and replacing of old and leaky service pipes and mains is vigorously prosecuted; (4) Distribution pipes are subdivided into numerous small districts with arrangements by Venturi meters, Deacon meters or other appliances for measuring in bulk the total supply drawn into each district.

With the greatest progress that can be reasonably expected in prevention of waste the consumption will probably not be decreased below present consumption within these next five years, because of (1) the time needed to educate the ordinary householder that general introduction of meters is to his benefit; (2) the time needed to establish systematic search for leaks and the great territory to be covered; (3) the large expenditure and extensive work needed for rearrangement of pipes for measuring supplies sent into the various districts.

Average Daily Consumption, in Million Gallons, of Croton, Bronx and Byram and Both Sources, 1884, and 1889-99, Inclusive with Forecast for Next 5 Years.

Year	1884.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.
Croton	84	86	103	142	155	165	163	166	186	197	207	226	242	256	270	284	297
Bronx and Byram	..	16	16	11	8·	10	13	14	15	15	19	20	18	18	18	18	18
Total	84	102	119	153	163	175	176	180	201	212	226	246	260*	274	288	302	315

*Although the Bronx and Byram have doubtless yielded 20,000,000 gallons per day in recent years, recomputation indicates safe yield in a series of dry years as not over 17,000,000, or perhaps not over 15,000,000 gallons per day. Therefore, in projecting line into the future, the deficiency is thrown on the Croton, and 2,000,000 gallons per day added to line.

be in four separate turrets; the first fore and aft on the keel-line; and the 8-in. turrets on the forward corners of the 6-in. casemate. As compared with the 13-in. guns of the "Oregon," which have a muzzle energy of 33,627 ft.-tons., the long 12-in. guns have a similar energy of 46,246 ft.-tons; and each of these 12-in. guns can be fired once in 90 seconds. The 8-in. guns are more powerful than the old 10-in. guns, and can be fired once in 50 seconds.

AMERICAN LOCOMOTIVES AND CARS IN EGYPT call forth from Lord Cromer, the British Minister and Consul-General in Egypt, the following explanation: He says that while the railway authorities prefer adhering to British locomotives, as the men are acquainted with their peculiarities, when time and cost are considered the British manufacturer cannot compete with the American. The latter offer engines, built on standard American plans, at lower prices and in less time than they can be secured from British or European builders. The British manufacturers, on the other hand, not being in the habit of building engines to standard plans of their own, content themselves with tendering on the designs of the Egyptian railway authorities; with the result that these specially made engines cost much more money and take much more time to build.

THE SUBMARINE TORPEDO BOAT "HOLLAND" has been purchased by the Navy Department for $150,000, on the following conditions: Of this sum $90,000 is deposited to complete the submarine boat "Plunger," now under construction at Baltimore. The government agrees to pay $175,000 each for any boat of the "Holland" type, but of larger dimensions. And the company agrees to protect the government against any claims for infringement of patents, and to sell to the government—at a price fixed by appraisement, any patents which the government may desire. The company also obligates itself to furnish experts to train a naval crew in the management of these boats.

THE WATER WASTE AND WATER SUPPLY OF NEW YORK CITY.

A valuable report on the present and future water supply of New York has been submitted to Mr. Bird S. Coler, Comptroller, by Mr. John R. Freeman, M. Am. Soc. C. E., of Providence, R. I. The report is voluminous, including many tables of run-off in the Croton drainage area and some 75 maps and drawings. Pending the publication of the full report a digest, without illustrations, has been printed. We are indebted to Mr. Freeman for a copy of this digest, and also for blue prints of some of the diagrams which will appear in the report. The bulk of the digest is devoted to a consideration of the present consumption and waste of water in Manhattan and the Bronx (old New York). The report shows most conclusively that water may be obtained from other sources than those offered by the Ramapo Company at a far less cost than its price of $70 per 1,000,000 gallons, and under as high a head as that which it has proposed to give.

Other salient points in the report are as follows: (1) The Croton, Bronx and Byram rivers, "with prudent management, and with moderate and practicable restriction of waste," may be relied upon to supply the boroughs of Manhattan and the Bronx for four or five years to come, at the end of which time an additional supply should be available; (2) that while there is proof that more than half the supply now delivered to these boroughs is absolutely wasted "the hope of restricting waste does not justify delay in making sure of an adequate additional supply;" (3) if for any causes there are delays in securing at least a "moderate additional supply," a "thorough system of waste-prevention, beginning properly with a meter on every domestic service, of necessity must be begun at once or danger of a water famine invited."

Besides these points, it is obvious to the thoughtful reader of the report, although Mr. Freeman does not emphasize it further than is necessary to support his argument, that woeful ignorance has prevailed hitherto regarding many conditions most vitally affecting the water supply of the city and that reliance has been placed on data based on wrong assumptions. As to the latter, the most significant conclusion drawn by Mr. Freeman is that previous official statements of the monthly run-off of the Croton from 1870 to 1895 average 10%, or 38,000,000 gallons a day above the actual amount. This, however, has little effect upon the estimated length of time the Croton yield will be sufficient for the old city, since, according to Mr. Freeman, the average daily consumption has been also overstated by estimating the carrying capacity of the old and new aqueducts at too high a figure, one error, or set of errors, thus offsetting the other.

The Croton Run-off, the Carrying Capacity of the Old and New Aqueducts, and Hence the Water Consumption all Over-Estimated.

Many strange things were discovered in this part of the study. First of all, Mr. Freeman notes that although the record books at the old Croton dam show two daily observations of the amount of water running to waste there, only one of these observations "had heretofore been used in the computation." In addition, no account had ever been taken of an obstruction, or step, at the south end of the dam's crest, 8 ins. high and 10½ ft. long. Still worse, perhaps, "no accurate experiments have ever been made" to determine the volume of water flowing over the crest for different depths on the gage. In the earlier years, an old formula of Eytelwein's was used in computing the flow. What was used later, Mr. Freeman does not say. To get nearer the truth, full scale models of the two parts of the old Croton dam, which Mr. Freeman describes as "of a peculiar form," were built in the canal at the Hydraulic Laboratory of Cornell University,

and very accurate and extended experiments upon the quantity of water discharged over them at various depths were made by Professor Williams. From these measurements it appears that the earlier estimates of the quantity of water wasted over the Croton Dam were about 8% too large.

The delivery of the old aqueduct, in earlier years, was not based on actual gagings,

but rested on the assumption that the coefficient of flow in this old Croton aqueduct, 30 to 50 years old, more or less obstructed by organic growths and deposits, was precisely the same as that in the new, smooth and clean Sudbury Aqueduct that had recently been completed for Boston and carefully gaged.

Through the co-operation of Messrs. A. Fteley, M. Am. Soc. C. E., then Chief Engineer of the Aqueduct Commission, and Mr. Geo. W. Birdsall, Chief Engineer of the Department of Water Supply, the old aqueduct was gaged anew. Mr. Fteley detailed Mr. F. W. Watkins, M. Am. Soc. C. E., Assistant Engineer, to assist in this work. The Fteley and Stearns current meter used to gage the new aqueduct was used. The new gagings and a study of all the other data available, indicated that the earlier estimates for full flow of the old aqueduct were too large by about 14,000,000 gallons a day.

What Mr. Freeman says about the gagings of the new aqueduct is given in full, as follows:

The flow in the new aqueduct had not been gaged since April, 1893, and in all previous estimates of consumption and yield, it has been assumed that the delivery in gallons for a given depth of water continued substantially the same as when the aqueduct was new. The velocity of flow in an aqueduct is reduced when organic growths collect on its interior, just as the speed of a ship is reduced when the bottom is foul. Experiments on two of Boston's masonry aqueducts have shown that the delivery may be 10% less after one year's collection of slime and organic growths on the interior, than when new.

I, therefore, had serious question if the New Croton Aqueduct, which had not been swept for nine years and not emptied for four years, might not have suffered serious impairment. Mr. Birdsall and Mr. Fteley, at my urgent request, again kindly co-operated in affording the opportunity for a new gaging, by which it is found that the carrying capacity has become impaired to the extent of 15%, or about 38,000,000 gallons per day, with water at the depth common during the past season.

This gaging was made by the same engineer who made the original gagings in 1891, 1892 and 1893, using the same instrument, and was repeated on four different days to make sure. The current meter was re-rated independently at the Massachusetts Metropolitan Water-Works and various comparisons and check measurements leave no doubt of the accuracy of this measurement.

There is independent evidence found in the declivity of the surface at various points which for analysis and explanation would take more space than can here be allowed, but indicates very strongly that there is a serious growth of spongilla or similar organic matter on the walls within the upper five miles of the new aqueduct. The water should certainly be withdrawn from the new aqueduct for one or two days at the very earliest opportunity and a thorough examination and cleaning be given it.

I also found that through inadvertence a mistake was made about 4½ years ago in setting the float gage by which the depths in the new aqueduct are measured, so that these have been exaggerated about 3 ins., leading to an over-estimate of from 4,000,000 to 10,000,000 gallons in the quantity daily consumed since that time.

In estimating the run-off from the Croton basin in earlier years, no allowance was made for the effect of storage reservoirs; and in later years some of the reservoirs have likewise been neglected. Proper corrections for these omissions have been made by Mr. Freeman, and are presented in detail in his full report. The corrected figures for the Croton drainage area "are presented in the belief that they form the most accurate measurement of long-term flow for so large a watershed yet available."

After making the various corrections noted, the average run-off of the Croton drainage area for the 32 years, 1868 to 1899, inclusive, is placed at 22.93 ins., against a rainfall of 47.83 ins., or 47.94% of the rainfall. Compared with the revised figures, those given in the 1895 report of the Aqueduct Commission for the years 1870 to 1895 average 10%, or 38,000,000 gallons a day too large.

Applying the revised Croton figures to the Bronx and Byram yields it appears that the aggregate of these should be placed at a total of 15,000,000 to 17,000,000 gallons a day, instead of 20,000,000 gallons, as heretofore.

After the completion of the new Croton dam, Mr. Freeman believes that the safe yield of the Croton drainage area will be 275,000,000 gallons a day, permanently, and "temporarily, under special care," but only with "taking some chances on impairment of quality of water, say, 300,000,000 gallons." Under present conditions, "with a repetition of the most severe drought of the past 32 years, the safe yield would be 232,000,000 gallons," or by adding flashboards to existing dams, and pressing into service special ponds not owned by the city, 250,000,000 gallons.

To get the available supply for Manhattan and the Bronx there should be added at least 15,000,000 gallons a day from the Bronx and Byram.

The average consumption of Croton water in 1899 was 226,000,000 gallons a day, and the daily consumption in the two boroughs has been increasing at the rate of 15,000,000 gallons a year for the past four years. Leaving the Bronx out of account, as a fixed supply, already wholly used, and comparing the consumption and waste of Croton in 1899, just given as 226,000,000 gallons, together with the yearly increase, with the above figures of possible Croton yield, Mr. Freeman concludes that there would be very little risk in relying upon the Croton supply for five years more, which would give ample time to supplement that source by another, provided work is begun immediately. Further storage in the Croton drainage area would be unwise, in view of the small total amount possible, and its great cost per million gallons, compared with the cost of possible supplies of large volume from other sources.

As to the use of flashboards for a temporary increase in storage capacity of the present reservoirs, pending the completion of the new Croton dam, Mr. Freeman thinks that 5,000,000 to 10,000,000 gallons a day could be secured by means

of soft steel rods from 1¼ to 1½ ins. diameter, placed vertically 20 ins. apart, against which flashboards from 2 to 4 ft. in height and of the cheap and safe type used for so many years on the Merrimac River Dam at Lawrence, Mass., should be placed.

This plan has been carried out, summer and winter, for over 20 years, at Lawrence. The soft steel rods yield when the pressure becomes too great. The boards are kept tight by "dusting them down" once or twice a day.

The Consumption and Waste of Water in Manhattan and the Bronx.

Fig. 1, including the notes on and below the diagram, gives the consumption and waste of water in the old city from 1884 to date, with estimates for the next five years, together with various comments on the same.

In 1899, the average daily per capita consumption and waste of water in New York was 116 gallons, of which the needless waste averaged at least 50, and more likely 70 gallons. Of the total waste probably not over ten gallons a day is incurable. With every tap metered, the meters kept in good repair, and leaks on the street side of the meters properly held in check

probably New York would be better served than now and have greater pressure in its pipes with a supply of 56 gallons per inhabitant per day than it now has with 116 gallons per inhabitant per day; or, to cover all uncertainty in above estimate of waste, if this be 50 instead of 70, the necessary supply would be 76 gallons.

The checking of this waste presents no difficult features, either engineering or financial, but instead:

The real difficulties about saving the water wasted rest in human nature and are questions of getting the voters to understand the truth of the matter, questions of public sentiment, politics and good government.

hoped for by Mr. Brackett has unfortunately not yet begun."

Mr. Freeman presents two estimates of future per capita consumption and waste in the old city, gives his ideas regarding the other boroughs, and then adds a word of caution, as follows:

Manhattan and the Bronx.	With the greatest effort to restrict waste that public sentiment will probably demand or support.*	With matters continued as at present.
In 1895, per capita.....	125 galls.	140 galls.
In 1900, "	130 "	155 "
In 1915, "	135 "	170 "
In 1920, "	140 "	180 "
In 1925, "	145 "	190 "
In 1950, "	150 "	200 "

*The remedy of the underground leakage must be slow. For Brooklyn and Queens the probable future consumption is taken at 80% of the above quantities. For Richmond, a still smaller consumption is estimated, based on the ordinary experience in similar communities.

It is dangerous to the public interests to be too hopeful about preventing waste when estimating the date when the new supply must be available, or in estimating its necessary magnitude, for with these hopes unfulfilled, and the reservoirs emptied, the disaster would then be beyond remedy.

The probable total additional quantities required for Manhattan and the Bronx, Brooklyn and Queens, Richmond, and for all boroughs, is given in the accompanying table, under ideal, probably attainable and present conditions of waste prevention.

From the figures in this table and other data, Mr. Freeman concludes that a source of additional supply should be sought immediately capable of furnishing at least 500,000,000 gallons a day. The greatest additional quantity obtainable from either Esopus Creek or the Ten Mile River alone would suffice for all the boroughs, only eight years under present conditions, and 12 to 15 years if half the services were metered at once and a reasonable amount of work done to stop leaks in mains and services.

Instead of proceeding along narrow lines, it is recommended that New York follow the plan pursued for Boston and vicinity, and make a comprehensive study of the needs and possible supply at a date far in the future.

Estimated Quantities Available and Costs for the Twelve Different Sources Considered.

Given "in the order of their economy and attractiveness," the twelve different sources of supply considered by Mr. Freeman are as follows:

(1) The Ten Mile River.—By means of a dam a little larger than the Titicus, the yield of 200 sq. miles of territory adjoining the Croton drainage area on the north could be turned into the East Branch of the Croton River, and a large storage reservoir formed capable of a safe dry weather yield of 150,000,000 gallons a day. This dam, such additional aqueducts or conduits as are necessary, and a 500,000,000-gallon terminal high pressure reservoir ½-mile north of the city limits, with a flow line 305 ft. above the sea, could be provided at a cost of $25,000,000. The aqueduct and terminal reservoir, in addition, would be capable of supplying 50,000,000 gallons a day from the present East Branch Reservoir.

The cost per 1,000,000 gallons, for this project, with 150,000,000 gallons a day from the Ten Mile River delivered under practically the same conditions as offered by the Ramapo contract (but with a storage reservoir at the city limits.—Ed.), would be less than $25, including maintenance, interest and sinking fund charges, sufficient to pay the whole cost in 40 years.

(2) Upper Housatonic and Ten Mile River Combined.—As this is Mr. Freeman's idea of a scheme worthy the future of Greater New York, we quote his outline in full:

The Upper Housatonic River combined with the Ten Mile River, the whole draining a water shed of over 1,000 square miles, in part the Berkshire Mt. region, can be controlled by a single dam, of the same size and height as the New Croton Dam now under construction, located in a narrow gorge between granite hills on the Housatonic River about one mile below Merwinsville, Connecticut, and with outlet dam and sluices as before at Pawling, N. Y. It is proposed that the flow line of the reservoir formed by this dam be at a level 455 ft. above sea. The area of the storage reservoir formed by the dam would be about 33 sq. miles, and a depth of draft of 30 to 35 ft. in the greatest drought of half a century, or a depth very much less than this in ordinary years would store sufficient water to sustain a delivery of 750,000,000 gallons per day.

Estimates of cost are based on a very complete reconnoissance in which separate estimates are made of all water powers affected. All houses within the submerged district were inspected and a rough appraisal made. The estimates of cost include stripping the southwest arm of the proposed basin near its outlet, over an area of about 4 sq. miles, removing all turf, roots and organic matter from this area, the same as has been done for the more recent reservoirs of Boston's supply, in order to improve the quality of water and lessening the chance of bad taste in summer due to organic growths. This stripping of reservoir beds has not been done on any part of New York's present storage systems. The estimate includes cost of an open canal down the ancient river channel from Pawling into the present East Branch Reservoir and for purchasing and draining the swamps along the East Branch River. From the present East Branch Reservoir the water would be taken through masonry aqueducts and tunnels over the same course already proposed for the Ten Mile Supply, but of course of larger size. The estimates provide for an aqueduct capacity sufficient to also convey the 50,000,000 gallons per day that the present East Branch Water Shed can yield, and 25% additional capacity is provided, 15% against impairment like that now existing in the New Croton Aqueduct, and 10% additional for temporary increase in demand. The estimates, as for the Ten Mile, include a terminal reservoir on the high ground at Park Hill, ½ mile north of the city limits, and for all structures, lands, water rights, dams and reservoirs necessary to supplying and delivering 750,000,000 gallons per day at the city limits, and also delivering the 50,000,000 of East Branch water at this higher elevation. The cost of the whole is estimated at about $47,000,000 for the whole 800,000,000 gallons per day.

The ground is everywhere favorable for delivering this water at the city limits at an elevation of 300 ft. above the sea, and with an ordinary friction loss in the pipes to the City Hall, water at this point or throughout substantially the whole of New York can be supplied from this soruce at a pressure of nearly 100 lbs. per. sq. in.

The cost of this water delivered at the city limits at 300 ft. elevation proposed by the Ramapo Co., if all divided upon the 750,000,000 gallons of new water, with no charge for bringing in the East Branch water at higher elevation, would be less than $10 per 1,000,000 gallons, including in this all interest and maintenance charges, allowance for depreciation, taxes, and an annual contribution to a sinking fund which at the end of 40 years would pay off all the bonds and turn the works over to the city in excellent condition fully paid for.

All of this water would not be wanted for many years to come. There can be no doubt that at some time within the life of those now active in business, it will all be wanted. If the entire cost be divided over only half the entire volume available, it is still wonderfully small for a supply which simply runs down hill by gravity into the city and arrives at the city limits with a head corresponding to the elevation of 300 ft. above the sea.

While New York has now no right to go over into Connecticut and seize upon the waters of the Housatonic River, and may indeed have no legal right under any grant that can be given by the New York Legislature to divert the Ten Mile River from flowing into Connecticut, it is probable that on the basis of commercial transactions and business procedure, rather than by eminent domain, so favorable a proposition could be made to the Connecticut Legislature, so fair and generous towards its citizens, that the necessary rights could be secured. The city to secure this location could afford to be generous to every house owner in the territory to be submerged; paying him, if need be, three times the fair ordinary market value of his house, his farm or his water power—and it is submitted that these citizens would naturally be anxious to trade, and each be desirous of taking his fair share of the $8,000,000 devoted to this purpose in the estimates.

On the other hand, it would be unwise in the extreme for the city to become definitely committed to seeking a supply in this direction until its options for these purchases under terms agreed on in advance were secured.

(3) Long Island, East of Present Supply Works.—With the removal of legislative restrictions, 100,000,000 gallons daily might be added to the present supply of Brooklyn by going farther east on Long Island. According to estimates made by Mr. I. M. De Varona, M. Am. Soc. C. E., in 1895, the above amount of water from this source, delivered into the Ridgewood Reservoir, Brooklyn, would cost $24,500,000. The cost per 1,000,000 gallons, "including pumping and all fixed charges at a higher rate of interest," but without sinking fund provisions, would be $39. Mr. Freeman estimates that the same quantity of water, developed under Project (2), just above, could be delivered from the proposed high pressure terminal reservoir into the Ridgewood Reservoir for $4,250,000, or $7 per 1,000,000 gallons, including the 40-year sinking fund and all other charges. This, added to the $10 for getting water from the Housatonic to the terminal reservoir, would make $17 per 1,000,000 gallons, against the $39 of Mr. De Varona's estimate, which estimate should, we suppose, be increased somewhat on sinking fund account, to make it wholly comparable with Mr. Freeman's own estimates. This, also, assumes that the construction estimates made in 1895 are applicable now.

(4) Drainage Area East of the Hudson and North of the Croton.—No figures of cost are given and no detailed studies appear to have been made. It might yield 150,000,000 to 200,000,000 gallons per day, or even more, and should be studied if the Housatonic project fails.

(5) The Poopolopen, Otter Kill, Walkill and Showangunk, west of the Hudson, deserve and are receiving detailed study, but no estimates are presented.

(6) Esopus Creek.—This drains 240 sq. miles of the southerly slope of the Catskills. Under plans filed by the Ramapo Co., and according to a report by Mr. Geo. S. Rice, M. Am. Soc. C. E., made last August, this source would yield, Mr. Freeman estimates, only 100,000,000 gallons a day. Possibly the dams proposed by the Ramapo Co. might be built higher, and additional drainage areas included to give a yield, "by straining the possibilities of storage," of 200,000,000 gallons a day. This, Mr. Freeman estimates, would cost between $40,000,000 and $50,000,000, while with operating expenses and a sinking fund, leaving the works in good repair and free of debt at the end of 40 years, the cost per 1,000,000 gallons would be only $35, or one-half the contract price which the Ramapo Co. come so near getting for water alone.

(7 and 8) The Ramapo and Mahway combined (7) might be made to yield 75,000,000 gallons a day, delivered at the city limits under a head of 300 ft., for $15,000,000, first cost. The Delaware River, at Port Jervis (8), is 60 miles from New York in an air line, and 410 ft. above the sea. The main river is not very promising. Certain tributaries might do, but the probable cost is prohibitive, regardless of interstate questions. More accurate studies might be made, perhaps, to advantage.

(9 and 10) Passing (9), which happens to be omitted from the digest, (10) suggests that an unlimited quantity of filtered water might be taken from the Hudson at Poughkeepsie, filtered, as the city just named is doing, and that 200,000,000 gallons a day might be delivered at 300 ft. elevation for $40 to $50 per 1,000,000 gallons, or $7 less, if delivered at the elevation of the present Croton supply.

(11 and 12) Water from the Upper Hudson (11) would show a high first cost, but 200,000,000 gal-

Probable Future Daily Requirements for Additional Water Supply of New York under Ideal, Probably Attainable and Present Conditions.

Year.		Manhattan and The Bronx. (U. S. gallons.)	Brooklyn and Queens. (U. S. gallons.)	Richmond. (U. S. gallons.)	Total all boroughs. (U. S. gallons.)
1910..	Probable population	2,600,000	1,800,000	90,000	4,490,000
	Additional supply required with greatest waste restrictions probably attainable. (Meters on one-half the domestic taps underground leak as much as at present.)	48,000,000	73,000,000	6,000,000(?)	127,000,000
	Addit'l supply needed under present conditions	113,000,000	109,000,000	8,000,000(?)	230,000,000
1920..	Probable population	3,200,000	2,200,000	130,000	5,530,000
	Additional supply probably required under ideal conditions of waste restriction	.....	31,000,000	7,000,000	38,000,000
	Additional supply needed under best waste restriction probably attainable	158,000,000	132,000,000	12,000,000	302,000,000
	Addit'l supply needed under present conditions	286,000,000	203,000,000	14,000,000	503,000,000
1930..	Probable population	3,800,000	2,600,000	175,000	5,575,000
	Additional supply probably needed under ideal conditions of waste restriction	14,000,000	68,000,000	10,000,000	92,000,000
	Additional supply needed under best conditions practically obtainable	280,000,000	198,000,000	19,000,000	597,000,000
	Addit'l supply needed under present conditions	470,000,000	302,000,000	23,000,000	795,000,000

as 11.2 gallons in Fall River, 16.3 in Lawrence, 14.1 in Woonsocket, and 14 in Worcester. The figures for these four cities include "such domestic waste as the average man permits to exist when he has a water meter in the cellar to quicken his memory and his interest in the repair of leaks."

Mr. Freeman believes that a very large number of inhabitants use small quantities of water each, and cites averages of many readings made for Mr. Dexter Brackett, ranging from 7 gallons per capita for 619 families in cheaper grades of houses in Newton, Mass., to 35.6 gallons for 339 apartment houses in Boston and 59 gallons for 31 high-priced apartments, also in Boston.

With waste prevention as well managed as in Fall River, Mr. Freeman thinks the real use and incurable waste of water in New York would be 55 gallons, divided as follows:

	Gallons.
Commerce and manufacturing	24
Domestic (including leaks inside houses.—Ed.)	15
Incurable waste outside houses	10
Under-registry of meters	3
Public uses	3
Total, each, for 2,000,000 people	55

These figures allow 61 gallons for curable waste, besides the 10 for incurable waste, or 71 for all waste, whereas the Central Park figures indicated 80 gallons.

A tentative distribution of waste in the order of magnitude, is given by Mr. Freeman as follows: (1) Leaky house plumbing; (2) old, leaky and abandoned service pipe, outside the house; (3) faucets left open "by the careless 10% or 20% of the householders;" (4) possibly a relatively small quantity through surreptitious connections.

Of the 50 or 70 gallons of waste, probably 30 to 50 gallons is due to defective plumbing and careless and wilful waste inside of buildings, "a waste from 3 to 4 times as great as the total actual use in the fully-metered cities." This may be called house waste, and two-thirds of it debited to poor plumbing. As to poor plumbing, its remedy, popular objections, and the answer thereto, Mr. Freeman says:

> The greatest cause of house waste is undoubtedly cheap and neglected plumbing fixtures, and among fixtures, tank ball-cocks are doubtless the greatest cause of leakage. The fastening of cocks open, letting the water run unnecessarily, is also a great source of waste. One cause of the smaller consumption in certain English cities is probably the rigid requirements for inspection of plumbing fixtures. In certain of the English cities every fixture must be officially inspected, approved and stamped before a plumber can use it, and this is believed to have greatly lessened the waste.
>
> Brightly polished fittings all look very much alike when new and considerable loss results in time from those which are light or soft or of cheap design, but with the compression cocks shutting against leather or rubber or fiber discs, common in all American plumbing, it is more often a question of neglect to apply a new disc or washer than of leakage caused by wear or yielding of the metal.
>
> For the underground plug cocks, the corporation cock, or the cellar stop and waste cock, there is a temptation to cheapen the cost of manufacture, by adding lead to the mixture of tin and copper or to use the cheaper alloy—soft "yellow brass," consisting only of a mixture of spelter and copper, thus giving a metal which can be worked in the lathe at high speed and with broad cuts.
>
> The experience in those American cities which are fully metered and whose domestic consumption has been already quoted, appears sufficient proof that each householder will become a fairly good inspector of leaky plumbing if he has a water meter in the cellar, and that reputable plumbers will supply their customers with proper fixtures without the inconvenience and expense of a government inspection, if the customer finds it to his pecuniary advantage to prevent waste of water through leaky fixtures.
>
> The great objection urged against meters is the fear that they will tend to a harmful restriction of the use of water in the houses of the poor or in tenement blocks where the landlord may not be of the most liberal class and would try to save water, if metered, at the expense of his tenants' comfort and health. This is a matter which can, I believe, be solved after proper study by some system of separate meters, combined with a carefully considered scale of minimum charges. The reliable answer is found in the test of experience. No complaint, so far as I am aware, now exists in Fall River, Providence, Worcester, Lawrence, Syracuse or Poughkeepsie that the comfort or health of any class in the community suffers because of the complete application of meters.

The waste underground in the streets of New York is, as a guess, 20 to 25 gallons per inhabitant a day. To locate and stop the leaks in the 1,500 miles of cast-iron mains and 200,000 services of Manhattan and Brooklyn would require, Mr. Freeman believes, "20 years of steady, patient, broadly-planned work," including with the above the finding, digging up and plugging off of some 25,000 abandoned services, "a part of which are without doubt leaking badly, and all of which are likely to leak sooner or later."

The Cure for Waste.

The first step recommended towards the stopping of the enormous waste shown to exist, is a subdivision of each borough into districts with an area of, say, ½ sq. mile, controlled by three gates; one gate to be in reserve and two provided with Venturi meters. By means of a variety of records, such as day and night and five-minute readings occasionally, and the population (1900 census), each district could be studied in detail and the aggregate for all the districts checked against the aqueduct delivery.

Having picked out the districts showing most waste, these should be completely metered, and at the same time all water used for public purposes should be determined. This done, there would be for the first time in New York, definite knowledge of the amount leaking out through all the leaky joints in main pipes and throughout all of the old, leaky and abandoned service pipes. The next step would be to subdivide the Venturi meter districts, and, being provided with large scale maps showing locations of all mains, services and gates, with their age where possible, make a thorough-going study of these smaller districts with the aid of Deacon meters. Unfortunately, this would locate leaks by blocks only, because of the absence of the usual curb stop-cocks on services in New York. Besides this, little permanent relief could be expected from the Deacon system in New York. Boston (with this and house to house inspection?—Ed.) did cut down the consumption from 91.5 gallons per capita in 1883, to 68 gallons in 1884, but it has risen since, until in 1899 it averaged a little higher in Boston than in old New York. Another objection to the Deacon system, as a permanent thing, is the corps of skilled observers it requires. This is to some extent true of house to house inspection, but in addition the latter is very objectionable to householders.

Mr. Freeman's final conclusions as to the best remedy for waste deserve the most careful consideration, particularly his recommendation of public ownership of both meters and the service pipes therefrom to the curb, and the proposition to have fewer services beneath the roadways:

> After having studied into these matters as thoroughly as possible in the time at my disposal, I am, from the evidence found in New York and in other cities, forced to conclude that *the one efficient, practical and economical method of preventing waste begins with a meter on every service pipe domestic as well as commercial.* At the same time it must be admitted that public sentiment in New York, as in Philadelphia and other large American cities, appears to be almost hopelessly against the universal application of domestic meters, for fear that tenement houses the health of the people will suffer from restriction of water and discouragement of cleanliness. That this comes from lack of understanding the matter fully, I have no doubt.
>
> It is my further opinion that the city should, at its own expense and through its own workmen put in all meters and that the meters should be periodically tested and kept in repair by the Public Water Department, and that the city should furthermore put in at its own expense and maintain all service pipes between the meter and the street main, and that systematic work in this direction should at once be begun, looking toward the city excavating and replacing all service pipes of whose tightness there is any doubt, at some fixed rate of progress per year, looking to the entire overhauling and remodeling of the mains within a period of say 20 years, relaying them with few mains arteries under the roadway, branching near the curb into the several buildings and with a curb stop-cock on the pipe into every building, at the same time making all new pipe thick and strong enough to stand a future working pressure of 100 lbs. per sq. in. Taking the work up in this manner, systematically, with the aim and end continually kept in view, of having all doubtful pipes re-laid and made good within 20 years, would not burden the water debt revenues seriously and the 20 years would quickly pass.

The universal meter system, he says, "is slowly but steadily gaining ground in the smaller American cities," all or a large percentage of taps now being metered in Fall River, Woonsocket, Providence, Worcester, Syracuse, Lawrence, Lowell, Milwaukee and Poughkeepsie. Everywhere the system has greatly reduced waste. The recent consumption per capita in these cities, notwithstanding much higher pressures, in some cases, than are maintained in New York, ranged from 29 gallons for Woonsocket (some factories supplied direct from river) to 68 gallons for Worcester. Practically all the services at Woonsocket and 94% at Worcester are metered. All the Woonsocket consumption and waste is measured at the pumps, while at Worcester it is recorded by a Venturi meter. At Worcester the service meters showed that of the total consumption 17 gallons per capita were used for manufacturing, 14 for domestic and 37 for public uses or not accounted for.

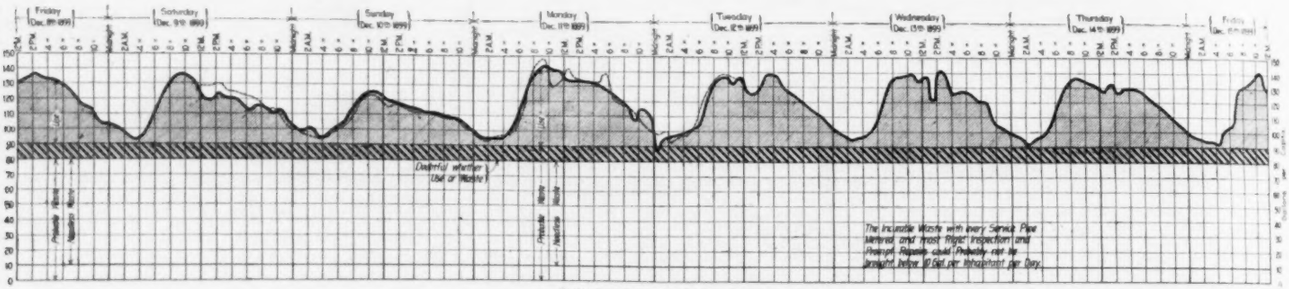


FIG. 2.—WASTE OF WATER IN NEW YORK, AS DETERMINED BY GAGINGS OF THE CENTRAL PARK RESERVOIR AND NEW CROTON AQUEDUCT.

Future Water Requirements of Greater New York.

The remarks under this head are very sensibly prefaced as follows:

> We must be governed by the facts as to what the public does now draw and the existing pipes now waste and by our best judgment as to what the public will use and the existing pipes continue to waste, rather than by our opinion of what the public ought to use, and above all our figure must be a safe one. The safe guide is to note that New York and Brooklyn now use less per capita than any of the other large American cities (with the single exception of St. Louis, where different conditions prevail) and to note that the rate of consumption per capita in New York is steadily increasing, and to further note what very eminent engineers, thoroughly familiar with all these facts regarding waste and the small proportion really used, have recommended in other cities. A large water supply cannot be had quickly, and if we get one that is too large at first, the growth of population will soon catch up with it.

Other recent estimates for new supplies for large populations were 150 gallons for Philadelphia, every tap to be metered (but having in mind the immense waste now prevailing there.—Ed.); 130 gallons for Cincinnati; and 100 gallons for the Boston Metropolitan District. The latter estimate was made by Mr. Dexter Brackett, M. Am. Soc. C. E., who, Mr. Freeman says, "probably has a richer fund of experience in water waste prevention to draw upon than any man in the United States." This 100 gallons per capita Mr. Brackett divided into 35 gallons for domestic use, 35 for manufacturing, 5 for public use and 25 gallons for waste. Four years later, or in 1899, the actual consumption in this district was 110 gallons, showing that "the reasonable and proper restriction of waste

lons a day might be delivered for less than $50, and 400,000,000 gallons for less than $40 a day. Lake George (12) is wholly out of the question (as the merest tyro of an engineer could see.—Ed.), but it has been suggested repeatedly. As a contribution to the attempt to down this Banquo's Ghost, we quote the few words with which it is dismissed by Mr. Freeman:

Lake George has often been suggested. The briefest investigation will show that its watershed is utterly inadequate to supply any such quantity as is needed for New York. The watershed is so small and the evaporating surface so large, that not more than 152,000,000 gallons per day in a dry year could be relied upon from this source, or no more than from the Ten Mile River alone. Its elevation, too, is about 222 ft. lower than the Hudson at the point of diversion at Corinth proposed and would not flow to New York, without pumping, at an elevation sufficient for use. Lake George should be dismissed from consideration as among the manifest impossibilities.

Pressure and Fire Protection.

The digest concludes with the recommendation, based on Mr. Freeman's 14 years of study of fire protection, as engineer to an association of insurance companies, that the new supply should afford a hydrant pressure of not less than 80 lbs., and preferably 100 lbs., followed by this paragraph:

It appears feasible to obtain this pressure throughout substantially the whole of New York from a gravity supply, and if the legal authority can be obtained to deliver 800,000,000 gallons per day from the Housatonic, Ten Mile and East Branch sources, with an elevation of 300 ft. above the sea at the city limits, this can be delivered at this elevation and pressure at a cost not substantially greater than if delivered at a lower level. This would do away with all necessity for high service pumping (which now costs the city in Manhattan alone about $75,000 per year for supplies and wages, apart from fixed charges and depreciation), would ultimately without doubt save largely in insurance cost, and presents such manifold advantages that it is earnestly recommended that all new work have the utilization of such a pressure in nearly all parts of the city, say 20 years hence, continually in view, or within 5 years in certain elevated or extra hazardous districts.

ACCIDENTS TO VESSELS IN NARROW CHANNELS AND THE PROPOSED GREAT LAKES AND ATLANTIC SHIP CANAL.

There is very serious doubt whether the great vessels of the lakes could be induced by any obtainable rates of freight habitualy to use a ship canal from the lakes to New York. Not only would the passage involve much time under ordinary circumstances, but the ship would be subjected both to the danger of accidents to herself in the contracted waterway and to serious detention through accidents to other ships. During the last season there were three accidents in the history of transportation on the lakes having a direct and marked bearing upon the subject of a ship canal from the lakes to tide water; illustrating as they do one of the serious and inevitable defects of such a highway of commerce.

In its natural condition, the St. Mary's River, which connects Lakes Huron and Superior, had extensive shallow reaches. Through these a channel has been excavated 300 to 400 ft. wide and 20 ft. deep. In the early part of September, 1899, one of the Great Lake freighters—the "Douglas Houghton," ore-laden—through the giving out of some of its steering gear, went aground; and swinging around across the channel, completely blocked it. It took five days of the most arduous and unremitting effort to get this vessel afloat and out of the channel; and, in the meantime, 332 vessels loaded with freight were unable to get by. To those interested this caused a dead loss estimated by the Lake Carriers' Association at nearly $1,000,000.

In the latter part of November, another blockade of the St. Mary's River channel occurred, due to a collision in which three vessels, two steamers and a tow barge, were mixed up and stranded. This caused a delay of nearly four days to some 167 vessels, and involved a loss to the navigation interests of a very large sum, probably not far from $500,000.

In the early part of December, a tow barge went aground in the St. Clair Flats canal, blocking the canal for nearly two days, delaying 35 vessels, and causing a heavy loss to the navigation interests. This latter accident, occurring just at the close of the season of navigation, might have produced most serious results by preventing a great many vessels from reaching their destination and home ports.

In spite of all possible precautions, such accidents are liable to happen in a contracted channel traversed by ships of 7,000, 8,000 or 9,000 tons capacity. The longer the channel, the greater is the liability to accident; and it is easy to imagine that in a ship canal from Lake Erie to Lake Ontario, and from Lake Ontario or the St. Lawrence River to New York, such accidents, blockades and detentions would be of frequent occurrence, if used by many vessels. Vessel owners and managers would naturally take all these dangers into consideration in determining whether or not to run their boats on such a canal, or in fixing rates of freight for carriage thereon. Of course, accidents and detentions are liable to occur on a small canal also; but, owing to the greater ease with which the smaller boats can be managed, the dangers here are not so marked. Besides, the results of accidents on a small canal are not likely to be so disastrous as those in the case of the greater canal, and with the larger boats. It is a much easier and quicker matter to lighter and float a small vessel, carrying a few hundred tons, than it is to do so with a great freighter, carrying several thousand tons. Moreover, it is the belief of many men familiar with matters relating to water transportation, that even if a ship canal were built, its business would be carried on not by the large vessels of the ocean or the lakes, but by barges of 1,000 to 2,000 tons capacity, which could be accommodated almost as well in a smaller and less expensive canal.—From a paper entitled "Canals from the Great Lakes to the Sea," by Major T. W. Symons, M. Am. Soc. C. E., Corps of Engineers, U. S. A., in "The Forum" for April.

(We have received from a well-known engineer the following comments upon the above statement by Major Symons.—Ed. Eng. News:)

In relation to the accident to the "Douglas Houghton" mentioned by Major Symons, it may be of interest to note that the conditions existing where the accident occurred are entirely different from those of an artificial waterway of similar dimensions. There is a sharp curve in the channel and a strong current at the point where the accident happened, and the only wonder is that similar accidents have not happened on the St. Mary's River channel oftener. On open rivers with strong currents the width of channel should not be less than 600 ft., instead of 300 ft., as on the St. Mary's River.

The Lake St. Clair Ship Canal is 300 ft. wide and 20 ft. deep, and is safely navigated by the largest lake freight steamers at speeds of 10 miles and more per hour. The current in the canal is about 1.7 miles per hour. In an artificial waterway of the same dimensions without any current beyond that due to lock supply, navigation would be much more safe than in the St. Clair Canal.

Major Symons is mistaken as to the location of the third accident which he mentions in his "Forum" article. It did not occur in the canal, but in the lake outside of canal piers, where the element of danger is much greater than in the canal.

STANDARD TRACK CONSTRUCTION; MEXICAN CENTRAL RY.

The Mexican Central Ry. is a standard gage line about 1,955 miles in length, and the accompanying cuts show the standard track construction. The most striking feature undoubtedly is the form of rail section, Fig. 1, with its wide and shallow head, its web radius of 12 ins. below and 24 ins. above the center line, and its round top corners, the latter feature being very much at variance with the majority of American practice. The following table gives the dimensions of the 75-lb. rail of the Mexican Central Ry. section, and the 75-lb. rail of the section recommended by the rail committee of the American Society of Civil Engineers, the latter form of section being now very extensively adopted as standard in this country:

	Mex. Central Ry.	A. S. C. E.
Height	5 ins.	4 29/32 ins.
Width of base	5 "	4 29/32 "
Width of head	2¾"	2 9/32 "
Side of head	Vertical.	Vertical.
Depth of head	1⅜ ins.	1 1/32 ins.
Height of web	2⅞ "	2 5/8 "
Depth of base	¾-in.	7/8-in.
Thickness of web	½-in.	11/32-in.
Edge of base	Vertical.	Vertical.
Height to c. of bolt hole	2 5/16 ins.	.....
Radius of top of head	15 ins.	12 ins.
" top corners of head	⅜"	3/32-in.
" bot'm corners of head	Sharp.	1/16-in.
" fillets	¼-in.	¼-in.
" sides of web	12 & 24 ins.	12 ins.
" corners of base	1/16-in.	1/16-in.
Fishing angles	12°	13°
Metal in head	.....	42%
" web	.....	21½
" base	.....	37%

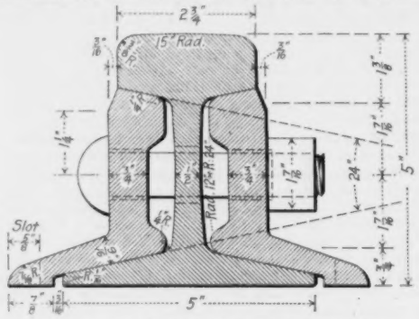


Fig. 1.—75-lb. Rail; Mexican Central Ry.

The rails are laid with square suspended joints, spliced by short heavy angle bars with four bolts, spaced 5 ins. c. to c., as shown in Fig. 2. The outer bolts are over the centers of the joint ties. The weight of the bars is 47.5 lbs. per pair. The bolts are ⅞-in. diameter in the body, with oval or elliptical necks fitting similar holes in the bar. They have the Harvey grip thread, and square recessed nut, no nut lock being used with this arrangement.

The ties are of all kinds, obtained from various points from Chicago to Texas, and along the company's lines. The standard dimensions are 8 ft. in length, and 6 × 8 ins. in section, but the section varies. A few thousand treated ties were laid last year. There are 16 ties to a rail length, and tie-plates are used at joints and on all ties on curves. The Wolhaupter tie-plate is shown in the cut, and several obsolete forms are also in use. The rails are secured by 6-in. spikes, ½-in. square. The ballast is of various materials, with a standard depth of 10 ins. under the ties.

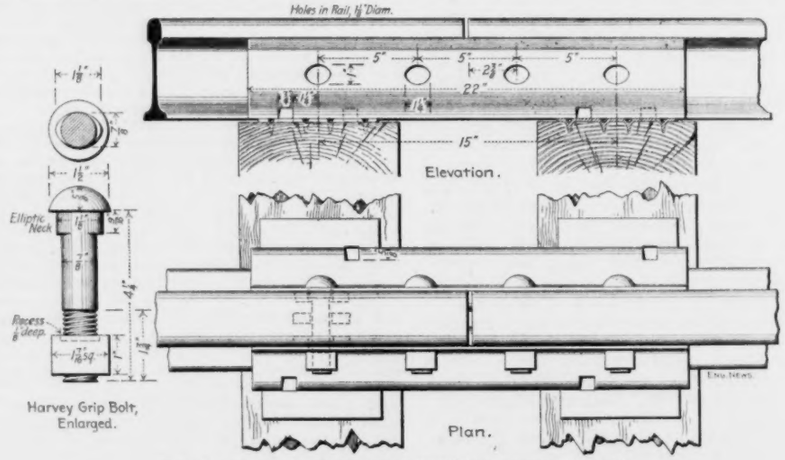


FIG. 2.—RAIL JOINT OF THE MEXICAN CENTRAL RY.

Rigid frogs are used, of the clamped and bolted patterns, No. 9 being the standard for main track, and Nos. 9 and 6½ for yards. The flangeway at guard rails is 2 ins. The Wharton split switch is standard, with switch points 15 ft. long, the switches being operated from rigid switchstands. The sharpest turnout in main track is of 14° 26', with a No. 6½ frog. All curves of 20° and sharper are fitted with guard rails, a flangeway of 2½ ins. being given.

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